# 8110A
# Digital Multimeter

## Instruction Manual

P/N 299479
November 1970
Rev. 3 11/71

FLUKE®

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# WARRANTY

Notwithstanding any provision of any agreement the following warranty is exclusive:

The JOHN FLUKE MFG. CO., INC., warrants each instrument it manufactures to be free from defects in material and workmanship under normal use and service for the period of 1-year from date of purchase. This warranty extends only to the original purchaser. This warranty shall not apply to fuses, disposable batteries (rechargeable type batteries are warranted for 90-days), or any product or parts which have been subject to misuse, neglect, accident, or abnormal conditions of operations.

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2. On receipt of the shipping instructions, forward the instrument, transportation prepaid. Repairs will be made at the Service Facility and the instrument returned, transportation prepaid.

**SHIPPING TO MANUFACTURER FOR REPAIR OR ADJUSTMENT**

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**CLAIM FOR DAMAGE IN SHIPMENT TO ORIGINAL PURCHASER**

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The JOHN FLUKE MFG. CO., INC, will be happy to answer all applications or use questions, which will enhance your use of this instrument. Please address your requests or correspondence to: JOHN FLUKE MFG. CO., INC., P.O. BOX C9090, EVERETT, WASHINGTON 98206, ATTN: Sales Dept. For European Customers: Fluke (Holland) B.V., P.O. Box 5053, 5004 EB, Tilburg, The Netherlands.

*For European customers, Air Freight prepaid.

**John Fluke Mfg. Co., Inc., P.O. Box C9090, Everett, Washington 98206**

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SECTION 1

# Introduction & Specifications

## 1-1. INTRODUCTION

1-2. The Fluke Model 8110A Digital Multimeter is a versatile, accurate instrument, which measures ac and dc voltage in four ranges to 1000 volts and ohms in five ranges to 10 megohms. Standard features of the Model 8110A include full guarding, a switched two-pole active filter, autopolarity, pushbutton function and range selection, and full four-digit readout plus "1" for overranging. Fluke's unique Recirculating-Remainder ($R^2$) A/D conversion technique enables multiple use of discrete and integrated components for the various operating modes, thereby reducing parts count and power consumption while increasing reliability.

1-3. Accessories and options for the Model 8110A include the rechargeable battery pack (Option -01), High Frequency Probe, High Voltage Probe, Switched AC/DC Current Shunts, Front Panel Dust Cover, and Rack Mount Kits. A detailed description of the battery option and each accessory is given in Section VI of the manual.

## 1-4. ELECTRICAL SPECIFICATIONS

### DC Volts

RANGE
±1, ±10, ±100, ±1000 volts dc with 20% overrange on all ranges.

RESOLUTION
0.01% of range (100 uv on 1v range maximum).

ACCURACY
90 days, 20°C to 30°C: ±(0.01% of input +0.01% of range).
6 months, 15°C to 35°C: ±(0.01% of input +0.02% of range).

DC INPUT RESISTANCE
Constant 10 megohms on all ranges.

FILTER
Switch selected two-pole, linear phase active filter.

SETTLING TIME TO RATED ACCURACY
0.25 seconds with filter out.
1.2 seconds with filter in.

REJECTION

| | | INTERFERENCE FREQUENCY | | | |
|---|---|---|---|---|---|
| | | 60 Hz | | 50 Hz | |
| | DC | FILTER IN | FILTER OUT | FILTER IN | FILTER OUT |
| CMRR (1K in Low Lead) | 120 db | 120 db | 100 db | 120 db | 100 db |
| NMRR | – – – | 60 db | 20 db | 47 db | 9 db |

*NOTE: CMRR = Common Mode Rejection Ratio*
*NMRR = Normal Mode Rejection Ratio*
*CMRR approaches infinity when instrument is battery operated.*

POLARITY
Automatic, instantaneous selection and display.

OVERLOAD
±1200 vdc or ±1700v peak ac can be applied continuously on any range without damage.

## AC Volts

RANGE
1, 10, 100, 1000 volts ac with 20% overrange on all ranges.

RESOLUTION
0.01% of range (100 uv on 1v range is maximum).

ACCURACY

| | MIDBAND 50 Hz to 10 kHz | EXTENDED 30 - 50 Hz & 10 - 20 kHz |
|---|---|---|
| 90 days, 15°C to 35°C | ±(0.2% of input + 0.05% of range) | |
| 6 months, 15°C to 35°C | ±(0.3% of input + 0.07% of range) | ±(0.5% of input + 0.1% of range) |

INPUT IMPEDANCE
1 megohm shunted by <30 pf.

SETTLING TIME TO RATED ACCURACY
2.8 seconds.

MAXIMUM DC NORMAL MODE VOLTAGE
±1200 vdc.

*NOTE: The sum of DC Normal Mode Voltage and peak ac voltage must not exceed ±1700v.*

OVERLOAD
±1200 vdc or ±1700v peak ac from 30 Hz to 20 kHz can be applied continuously on any range without damage.

## Resistance

RANGE
1k, 10k, 100k, 100k, and 10 MΩ with 20% overrange on all ranges.

RESOLUTION
0.01% or range (0.1 ohm on 1k range is maximum).

ACCURACY

| | 1k to 1000k | 10M |
|---|---|---|
| 90 days, 20°C to 30°C: | ±(0.02% of input + 0.01% of range) | ±(0.05% of input + 0.01% of range) |
| 6 months, 15°C to 35°C: | ±(0.02% of input + 0.02% of range) | ±(0.1% of input + 0.2% of range) |

CONFIGURATION
Two terminal, constant current.

VOLTAGE ACROSS INPUT
1.0v at full range.
1.2v at 20% overrange.
9v with open terminals.

POWER IN UNKNOWN R
⩽ 1 milliwatt in range and ⩽ 1.44 milliwatts at 20% overrange on the 1K range, decreasing by an order of magnitude per range to 100 nanowatts at 10 megohms.

SETTLING TIME TO RATED ACCURACY

| | 1k to 1000k | 10M |
|---|---|---|
| Filter Out | 0.25 seconds | 2.8 seconds |
| Filter In | 1.8 seconds | 10.0 seconds |

OVERLOAD

| | |
|---|---|
| 1k Range | 130 vrms may be applied indefinitely without damage. |
| 10k to 10 MΩ | 230 vrms may be applied indefinitely without damage. |

MAXIMUM INPUTS

| | |
|---|---|
| HI to LO | See OVERLOAD specifications by function. |
| LO to GUARD | 100 vdc or peak ac. |
| GUARD to chassis | 1200 vdc or 230v rms at 60 Hz. |

POWER
8 watts from 115V/230V, ±10%, 50 to 500 Hz line with internal battery option –01. Eight hours continuous operation from the rechargeable nickel-cadmium batteries.

## 1-5. ENVIRONMENTAL SPECIFICATIONS

HUMIDITY RANGE
Meets all specifications to 80% relative humidity for temperatures ⩽ 35°C and 70% relative humidity for temperatures 35°C to 50°C.

SHOCK AND VIBRATION
Meets requirements of MIL-T-21200 G and MIL-E-16400F.

STORAGE TEMPERATURE
–40°C to +75°C.
–40°C to +60°C for batteries.

### Operating Temperature
0°C to +50°C.

### Temperature Coefficient

| FUNCTION | TEMPERATURE COEFFICIENT |
|---|---|
| DC Volts | ±(0.0015% of input + 0.001% of range)/°C |
| AC Volts | ±(0.015% of input + 0.005% of range)/°C |
| KΩ | ±(0.003% of input + 0.001% of range)/°C |
| 10 MΩ | ±(0.008% of input + 0.001% of range)/°C |

*NOTE: Add temperature coefficient only outside of temperature limits noted in 30 and 90 day specifications.*

## 1-6. MECHANICAL SPECIFICATIONS

### Weight
8 pounds without batteries.
10 pounds with batteries.

### Mounting
Carrying handle detents into custom non-marring feet and serves as a tilt-up bail for bench use. The Model 8110A outline drawing is shown in Figure 1-1, with approximate overall dimensions.

## 1-7. GENERAL SPECIFICATIONS

### Selection
Function and range selection is manual via mechanically interlocked pushbutton switches.

### Display
Four decade neon in-line readout with polarity neon for dc volts and fifth digit for 20% overrange. Automatic decimal location.

### Sample Rate
Three samples per second.

### Accessories Available
80-RF - R.F. Probe, 500 MHz
80F-5 - High Voltage Probe, 5 kv
80F-15 - High Voltage Probe, 15 kv
A90 -6 Range AC/DC Current Shunt to 10A
MEE-4008 - Front Panel Dust Cover
MEE-7006 - Rack Mtg. Ears - Single Unit, Center Mount
MEE-7013 - Rack Mtg. Ears - Single Unit, right and left offset.
MEE-7104 - Rack Mtg. Kit - Two Units, side-by-side

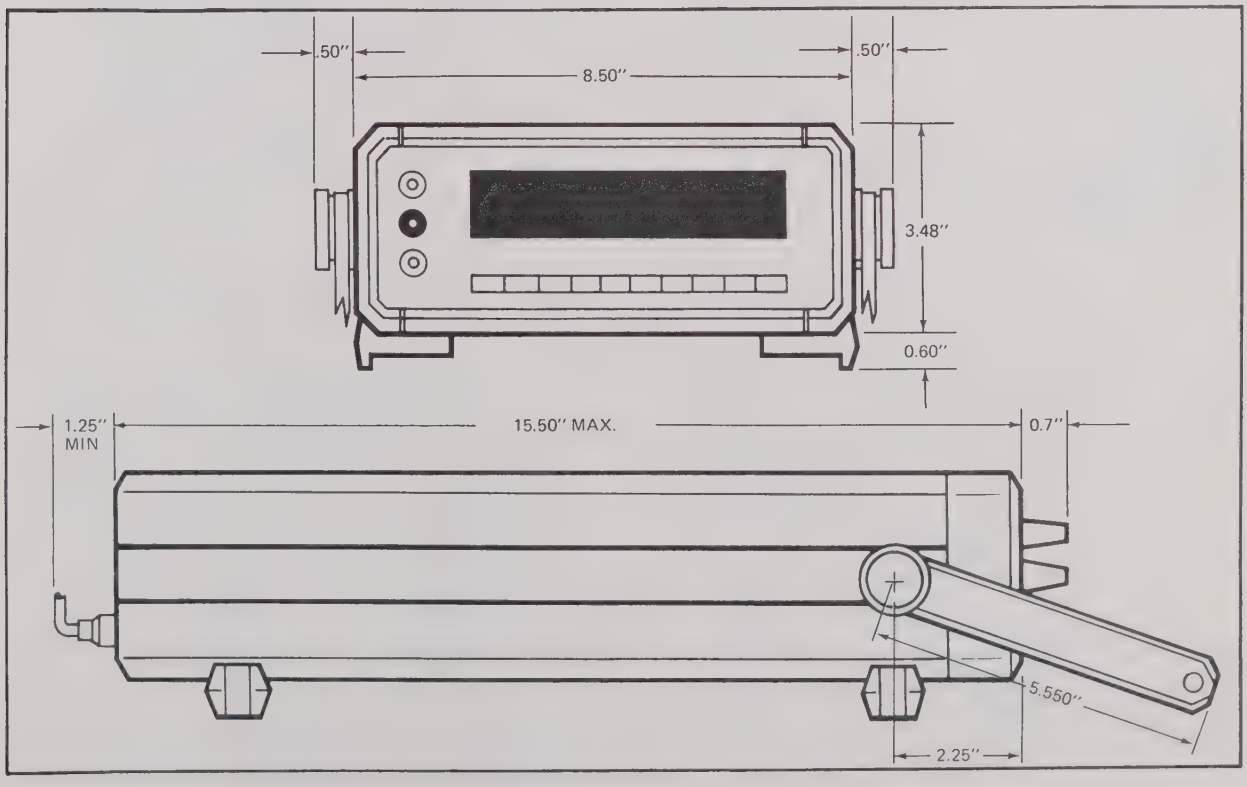
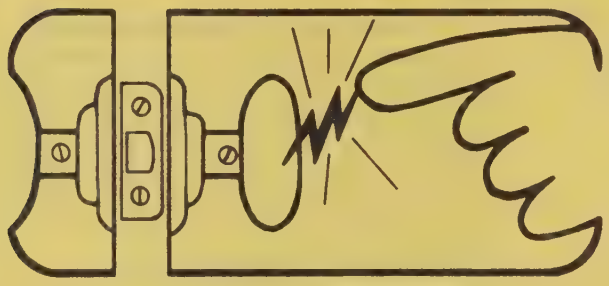



Figure 1-1. MODEL 8110A OUTLINE DRAWING

# static awareness

A Message From

**John Fluke Mfg. Co., Inc.**

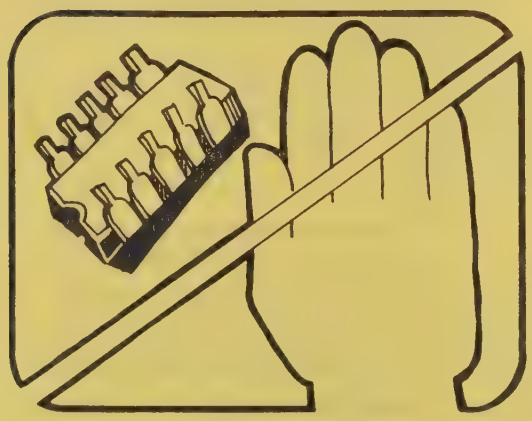


Some semiconductors and custom IC's can be damaged by electrostatic discharge during handling. This notice explains how you can minimize the chances of destroying such devices by:

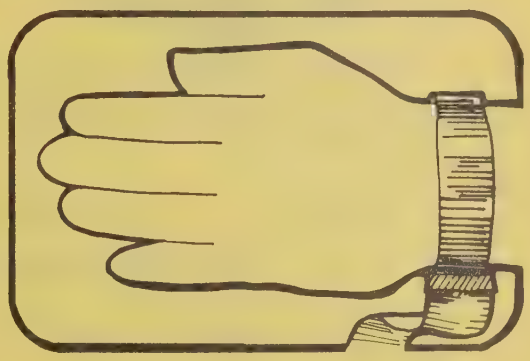
1. Knowing that there is a problem.
2. Learning the guidelines for handling them.
3. Using the procedures, and packaging and bench techniques that are recommended.

The Static Sensitive (S.S.) devices are identified in the Fluke technical manual parts list with the symbol "⊗"

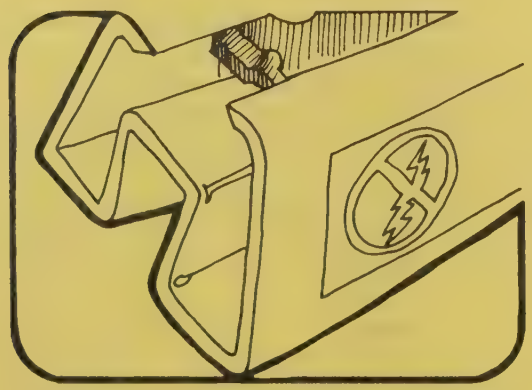
The following practices should be followed to minimize damage to S.S. devices.



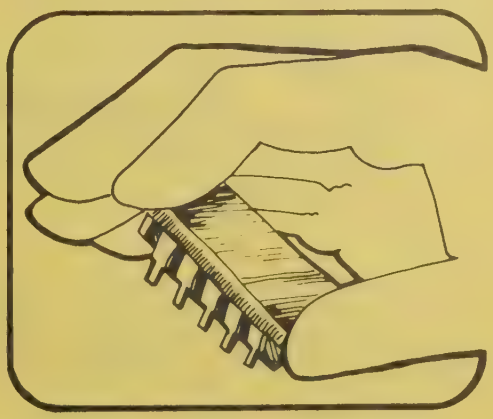
1. MINIMIZE HANDLING



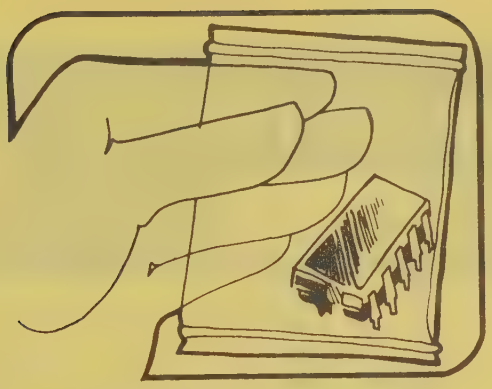
3. DISCHARGE PERSONAL STATIC BEFORE HANDLING DEVICES



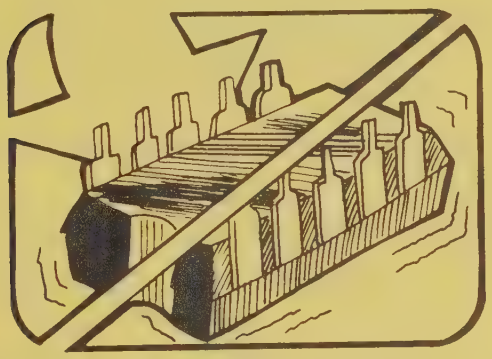
2. KEEP PARTS IN ORIGINAL CONTAINERS UNTIL READY FOR USE.



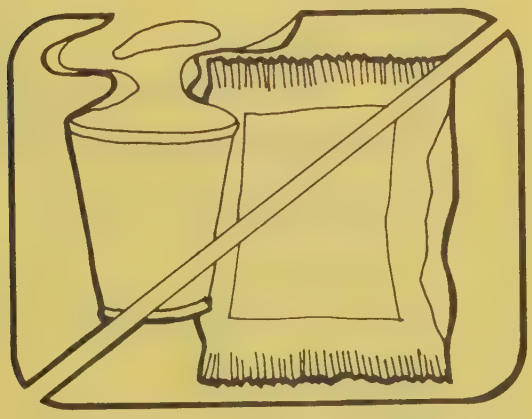
4. HANDLE S.S. DEVICES BY THE BODY



5. USE ANTI-STATIC CONTAINERS FOR HANDLING AND TRANSPORT



6. DO NOT SLIDE S.S. DEVICES OVER ANY SURFACE



7. AVOID PLASTIC, VINYL AND STYROFOAM® IN WORK AREA

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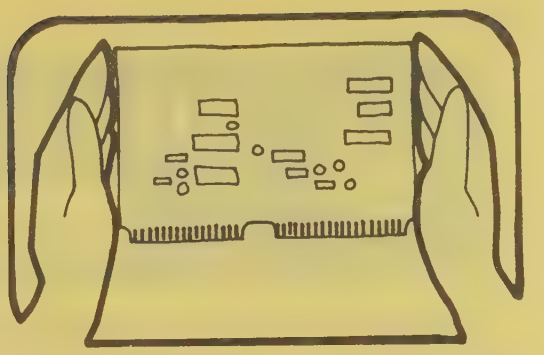
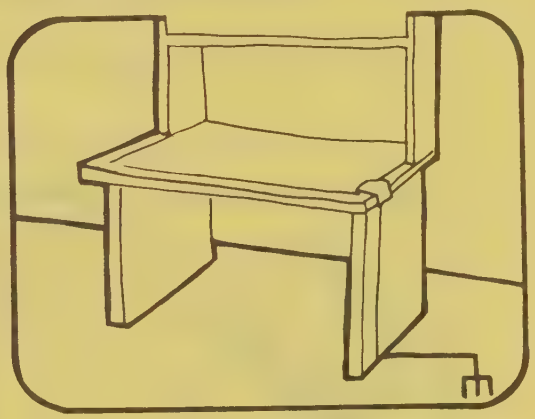
AND GENERAL DYNAMICS, POMONA DIV.

® Dow Chemical



8. WHEN REMOVING PLUG-IN ASSEMBLIES, HANDLE ONLY BY NON-CONDUCTIVE EDGES AND NEVER TOUCH OPEN EDGE CONNECTOR EXCEPT AT STATIC-FREE WORK STATION. PLACING SHORTING STRIPS ON EDGE CONNECTOR USUALLY PROVIDES COMPLETE PROTECTION TO INSTALLED SS DEVICES.



9. HANDLE S.S. DEVICES ONLY AT A STATIC-FREE WORK STATION

10. ONLY ANTI-STATIC TYPE SOLDER-SUCKERS SHOULD BE USED.

11. ONLY GROUNDED TIP SOLDERING IRONS SHOULD BE USED.

---

Anti-static bags, for storing S.S. devices or pcbs with these devices on them, can be ordered from the John Fluke Mfg. Co., Inc.. See section 5 in any Fluke technical manual for ordering instructions. Use the following part numbers when ordering these special bags.

| John Fluke Part No. | Description |
|---|---|
| 453522 | 6" X 8" Bag |
| 453530 | 8" X 12" Bag |
| 453548 | 16" X 24" Bag |
| 454025 | 12" X 15" Bag |
| Pink Poly Sheet 30"x60"x60 Mil P/N RC-AS-1200 $20.00 | Wrist Strap P/N TL6-60 $7.00 |



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# SECTION 2
# Operating Instructions

## 2-1. INTRODUCTION

2-2. This section contains operating instructions and applications information for the Model 8110A Digital Multimeter. Included in the instructions is a detailed description of the instrument controls, terminals, and indicators and an operational check, which verifies satisfactory operation of the instrument using only front panel controls. If any problem is encountered in operating the instrument, contact the nearest John Fluke Sales Representative or write directly to the John Fluke Manufacturing Company. Please include the instrument serial number when writing.

## 2-3. INSTALLATION

2-4. The Model 8110A is supplied with non-marring feet and tilt-down bail for bench or field use. Rack mounting kits for installation of one instrument or two instruments side-by-side in a standard 19 inch rack are available as accessories and are described in Section VI of the manual.

## 2-5. REPACKAGING FOR SHIPMENT

2-6. This instrument was packed and shipped in a foam-backed cardboard carton. If reshipment is required, the original container should be used, if available. Upon request, a new container can be obtained from the John Fluke Mfg. Co., Inc. Please include instrument model number when requesting a new container.

## 2-7. ACCESSORIES

2-8. The following Model 8110A accessories are available at additional cost. A detailed description of the accessories is given in Section VI of the manual.

High Frequency Probe
High Voltage Probes
Switched AC/DC Current Shunts
Front Panel Dust Cover
Rack Mount Kits

## 2-9. INPUT POWER REQUIREMENTS

2-10. The instrument operates on either 115 or 230 volt, 50 Hz to 500 Hz ac power or directly from the optional battery pack. Before applying ac power to the instrument, remove the bottom dust cover and note the position of the 115/230 volt slide switch at the rear of the instrument. If the switch does not indicate the desired operating voltage, proceed as follows:

a. Place the 115/230 volt switch in the position that corresponds to the desired operating voltage.

b. Ensure that the proper line fuse for the selected voltage is installed before operating the instrument. For 115 volt operation, the fuse should be 1/8 ampere slow-blow and for 230 volt operation, the fuse should be 1/16 ampere slow-blow.

c. Replace the bottom dust cover and connect the instrument to the line.

**WARNING!**

**The round pin on the polarized three-prong plug connects the instrument case to power system ground. If a three-to-two-wire adapter is used or if the instrument is powered from batteries with the line cord disconnected, ensure that the instrument case is connected to a**

**high quality earth ground. This can be done by connecting a wire between the center pin on the rear panel ac connector and earth ground.**

2-11. The optional battery pack supplies the operating power for the instrument whenever the ac power cord is disconnected from the ac line. The battery is charged by connecting the instrument to the ac line and turning the instrument on. The front panel meter monitors the charge on the battery during battery operation and during line operating it indicates LINE OPR (full scale). A detailed description of the battery option is provided in Section VI of the manual.

## 2-12. OPERATING FEATURES

2-13. The name and function of the front and rear panel controls, terminals, and indicators are shown in Figure 2-1.

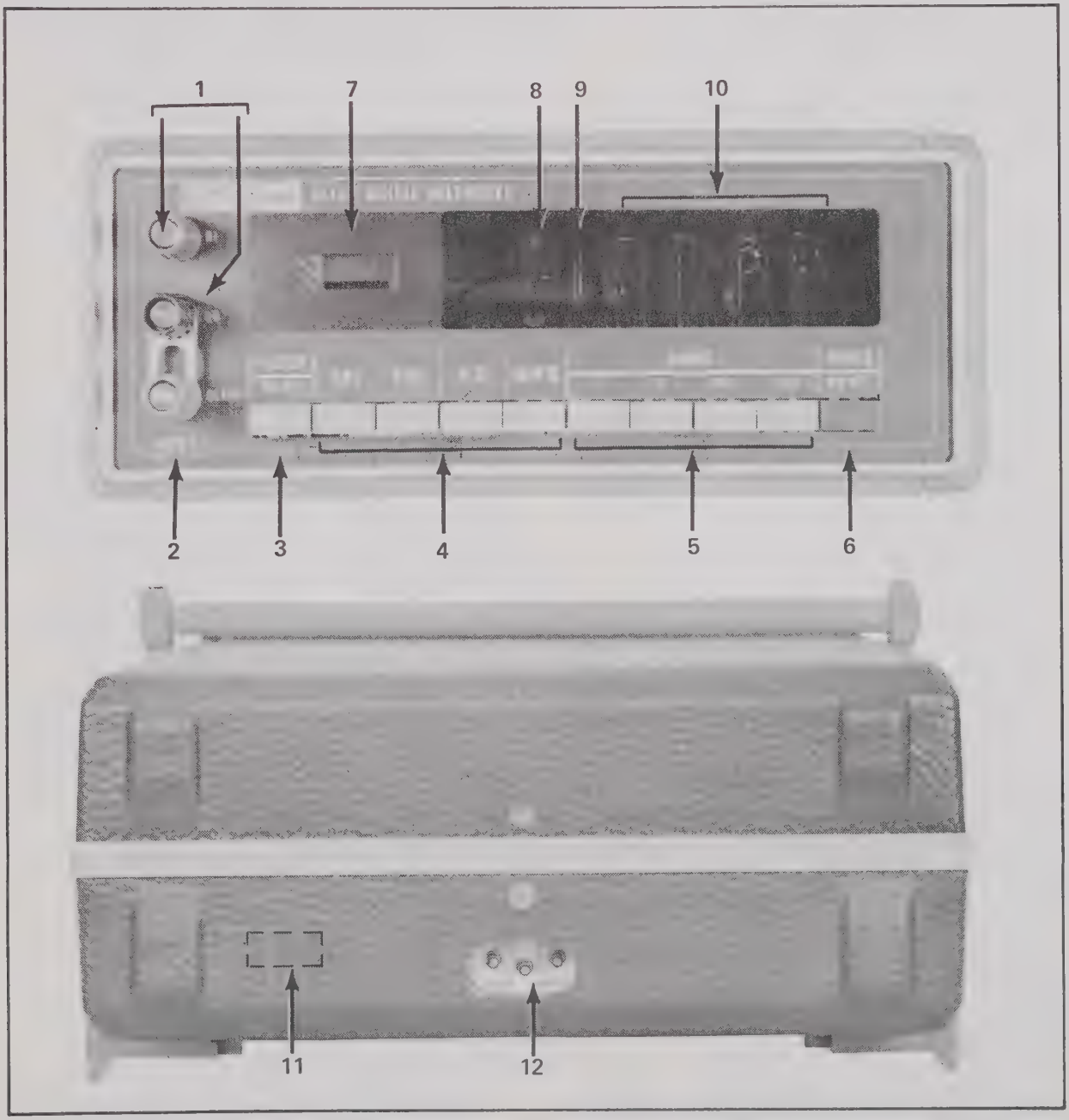



Figure 2-1. CONTROLS, TERMINALS, AND INDICATORS (Sheet 1 of 2)

| REF. NO. | NAME | FUNCTION |
|---|---|---|
| 1 | INPUT Terminals | Input connections for dc voltage, ac voltage, and resistance measurement. |
| 2 | GUARD Terminal | Connects to internal guard chassis. When properly connected externally, provides increased ac and dc common mode rejection. GUARD terminal may be connected directly to the LO terminal or disconnected from the LO terminal and driven by a separate GUARD potential. |
| 3 | FILTER ON–OFF Switch | Push ON-push OFF switch selects the two-pole active input filter when depressed (ON) and reduces the amount of filtering when released (OFF). |
| 4 | Function Switches | Four pushbutton switches select the desired operating mode: VAC (ac voltage mode), VDC (dc voltage mode). KΩ (Kilohm mode), and 10 MΩ (10 megohm mode). |
| 5 | RANGE Switches | Four pushbutton switches select the full-scale input range for voltage or resistance measurement. Ranges of 1, 10, 100, and 1000 are provided for each function except 10 MΩ, which is fixed independent of the RANGE switch . |
| 6 | POWER ON-OFF Switch | Push ON - push OFF switch controls input power to the instrument. When depressed, instrument is ON; when released, instrument is OFF. |
| 7 | Battery Meter | Indicates charge condition of battery when the battery option is installed and the instrument is operating from the batteries. When the instrument is on the line and the batteries are charging, the meter indicates LINE OPR (full scale). |
| 8 | Polarity Indicator | Neon indicator tube indicates "+" when positive voltages are applied to the instrument and "–" when negative voltages are applied to the instrument. |
| 9 | Overrange Indicator | Neon indicator displays "1" for full-scale readout and 20% overrange on each range. When a maximum overrange input is applied to the instrument, in any operating mode, the readout will be 11999, with the decimal point positioned according to range. |
| 10 | Readout Tubes | Neon indicator tubes display the instrument readout from left to right, with the most significant digit displayed by the left-most tube. Each tube also displays a decimal point which, is operated by the RANGE switches. |
| 11 | 115/230 Volt Switch | Slide switch selects the ac operating voltage for the instrument. Switch is not accessible until bottom dust cover is removed. NOTE: Refer to paragraph 2-9 for conversion instructions. |
| 12 | AC Line Connector | Mates with three-wire line cord for connection to 115/230 volt, 50 Hz to 500 Hz ac line. |

Figure 2-1. CONTROLS, TERMINALS, AND INDICATORS (Sheet 2 of 2)

## 2-14. OPERATIONAL CHECK

2-15. This test verifies satisfactory operation of the instrument, using only front panel controls. It is intended as a quick functional check only. The tolerances on readouts have been calculated for an ambient temperature of 25°C ±10°C.

a. Connect the Model 8110A to a source of 50 Hz to 500 Hz ac power or use the optional battery pack, as described in paragraph 2-9.

b. Set the controls and make the connections shown in Table 2-1. The readout should be as indicated.

2-16. A detailed performance test is given in the Maintenance section of the manual. It verifies performance of the instrument within the basic accuracy specifications using standard input signals and front panel controls only. It is suggested for use as a receiving inspection test for the instrument and to determine if the instrument is in calibration.

## 2-17. DC VOLTMETER OPERATION

2-18. The Model 8110A measures dc voltages in both polarities from 0 to 1000 volts, with 20% overrange capability in each of the four ranges. An active 2-pole filter is included and provides two modes of filtering. It may be switched in, if desired, to reduce the instrument response to noise. To operate the instrument as a dc voltmeter, proceed as follows:

a. Press the VDC function switch to place the instrument in dc voltage mode.

b. Select the desired full-scale voltage range by pressing the corresponding RANGE switch.

c. Select increased noise rejection by operating the FILTER switch (see filter specifications in the Section I). Note that response time to rated accuracy is increased from 0.25 seconds to 1.2 seconds with filter IN.

Table 2-1. MODEL 8110A OPERATIONAL CHECK

| MODEL 8110A CONTROL SETTINGS AND CONNECTIONS | | | | READOUT |
|---|---|---|---|---|
| FUNCTION | RANGE | FILTER | INPUT TERMINALS | |
| VDC | 1000 | ON | OPEN | 000.0 ±1 digit |
| | 100 | ON | SHORTED | 00.00 ± 1 digit |
| | 10 | ON | SHORTED | 0.000 ± 1 digit |
| | 1 | ON | SHORTED | .0000 ± 1 digit |
| VAC | 1000 | – | SHORTED | 000.0 to 000.3 |
| KΩ | 1 | ON | OPEN | 1.1999 (instrument attempts to measure infinite resistance at input terminals) |
| | 1 | ON | SHORTED | .0000 to .0002<br>NOTE: Resistance of connections and shorting link must be less than 100 milliohms to obtain indicated reading. |
| 10 MΩ | – | ON | OPEN | 11.999 |
| | – | ON | SHORTED | 0.000 to 0.001 |

d. Connect the voltage to be measured to the INPUT terminals. The automatic polarity circuitry of the Model 8110A will activate appropriate circuitry in the instrument and the front panel polarity indicator will register a "+" if the HI input terminal is positive with respect to the LO terminal and "–" if the HI input terminal is negative with respect to the LO terminal.

## 2-19. AC VOLTMETER OPERATION

2-20. The Model 8110A measures ac voltage from 0 to 1000 volts at frequencies of 30 Hz to 20 kHz, with 20% overrange capability in each of four ranges. To operate the instrument as an ac voltmeter, proceed as follows:

a. Press the VAC function switch to place the instrument in ac voltage mode.

b. Select the desired full-scale voltage range by pressing the corresponding RANGE switch.

c. Connect the voltage to be measured to the INPUT terminals.

## 2-21. OHMMETER OPERATION

2-22. The Model 8110A measures resistance in five full-scale ranges of 1k, 10k, 100k, 1000k, and 10 megohms, with 20% overrange capability in each range. To operate the instrument as an ohmmeter, proceed as follows:

a. Select the KΩ function switch for measurement of resistances between 0 and 1000k and select the 10 MΩ switch for measurement of resistances between 1 and 10 megohms.

b. Select the desired full-scale resistance range in kilohm mode by pressing the corresponding RANGE switch. In 10 megohm mode, the range is fixed independent of the four range switches.

c. Connect the resistance to be measured to the INPUT terminals.

*NOTE!*

*In both KΩ and 10 MΩ modes, the internal voltage arrangement is such that the HI input terminal is positive with respect to the LO input terminal.*

## 2-23. OPERATING NOTES

### 2-24. Overload Protection

2-25. The Model 8110A is fully protected against overload in each function and on all ranges. In ac and dc voltage modes, ±1200 volts dc or 1700 volts peak ac from 30 Hz to 20 kHz can be applied indefinitely on any range without damage. In ohms mode, 130 volts rms may be applied indefinitely on the 1 kilohm range without damage, and 230 volts rms may be applied indefinitely on the remaining ohms ranges without damage.

### 2-26. Use of Guard Terminal

2-27. The instrument contains an isolated inner chassis, which is connected to the GUARD terminal on the front panel. When properly connected, the guard chassis reduces measurement errors due to common-mode currents. Ordinarily, the GUARD terminal is strapped to the LO terminal; however, it may also be driven by a separate guard voltage, with connections at a remote point. It should be noted that the guard voltage must be within 100 volt dc or peak ac of the LO input terminal.

## 2-28. APPLICATIONS

### 2-29. Transistor Testing

2-30. In KΩ and 10 MΩ modes, the Model 8110A produces a maximum of 9 volts, with 10 kilohms to 10 megohms in series, depending on range. The maximum current flowing in the unknown resistance is 0.7 milliamp. The maximum power dissipated in the unknown resistance is 2.0 milliwatts on the 1 kilohm range, decreasing by an order of magnitude per range to 200 nanowatts maximum at 10 megohms. Consequently, the instrument may be used to safely test most transistors. In both KΩ and 10 MΩ modes, the internal voltage arrangement is such that the HI input terminal is positive with respect to the LO terminal.

### 2-31. DBM Measurement

2-32. To use the Model 8110A as an ac output meter, terminate the circuit to be measured in its characteristic impedance and connect the Model 8110A directly across the load. For example, to measure output levels of a circuit having a characteristic impedance of 600 ohms, connect a 600-ohm load to the Model 8110A INPUT terminals. The resulting readout may be converted to dbm using the information provided in Table 2-2.

Table 2-2. AC VOLTAGE TO DBM CONVERSION TABLE FOR 600-OHM CIRCUITS

| MODEL 8100A READOUT | DBM LEVEL FOR 1 VOLT RANGE (1 mw in 600 Ω) |
|---|---|
| .0138 | −35 |
| .1092 | −17 |
| .2182 | −11 |
| .3083 | − 8 |
| .4352 | − 5 |
| .5490 | − 3 |
| .6150 | − 2 |
| .6897 | − 1 |
| .7746 | − 0 |
| .8700 | + 1 |
| .9760 | + 2 |
| Add 20 db for each range above one volt. | |

## 2-33. Measurement of High Resistances

2-34. In this application, the Model 8110A together with a stable external dc voltage are used to measure resistances in excess of 10 megohms.

a. Measure and record the external voltage, $E_{bb}$; then connect the equipment as shown in Figure 2-2.

b. Record the Model 8110A readout.

c. Using the following calculations, determine the value of the unknown resistance, $R_x$.

$$R_x = \left( \frac{E_{bb}}{E_m} - 1 \right) R_m$$

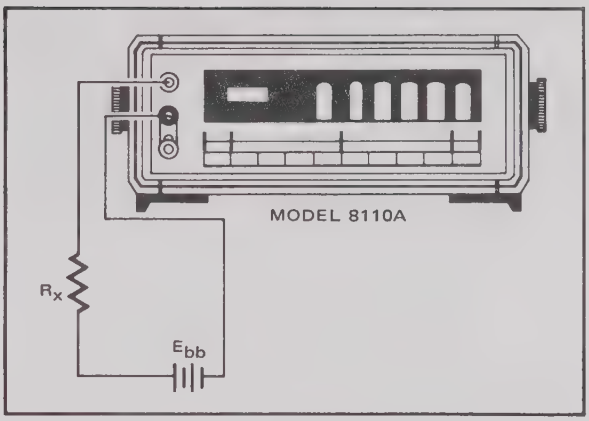



Figure 2-2. CIRCUIT CONNECTIONS FOR MEASUREMENT OF HIGH RESISTANCES

Where $E_{bb}$ = External DC Voltage (volts dc)
$E_m$ = Model 8110A readout in step b. (volts dc)
$R_m$ = 10.01 MΩ ±0.05% (8110A input resistance)

## 2-35. Use As A Null Detector

2-36. The Model 8110A, with battery option, is ideally suited to many applications requiring a null detector. The high dc input resistance (10 megohms) and the autopolarity feature of the instrument make it ideal for monitoring small voltage differences in bridge circuits, potentiometers, and other measuring devices. Where circuit adjustment is required, the circuit is simply adjusted for a readout of all zeros on the Model 8110A, which provides 100 microvolt resolution on the 1 volt range.

SECTION 3

# Theory of Operation

## 3-1. INTRODUCTION

3-2. This section contains the theory of operation of the Model 8110A Digital Multimeter. In the general discussion, the instrument function is examined at the block diagram level. The detailed circuit description is keyed to the schematics at the back of the manual.

## 3-3. GENERAL THEORY

### 3-4. System Description

3-5. The Model 8110A consists of three main sections: the buffer, the analog-to-digital (A/D) converter, and the display. A simplified block diagram of the instrument is shown in Figure 3-1. The buffer accepts the input signal and converts it into a voltage suitable to drive the A/D converter. It scales and conditions all inputs and it performs ac to dc conversion. The A/D converter accepts the buffer output, determines the polarity of the voltage, and converts the voltage into a binary coded decimal (BCD) output. The analog storage circuit is used to retain digit information between measurement cycles so that a continuous display is provided. The display circuit accepts the BCD output from the A/D converter and converts it into a 10-line decimal output, which operates the readout tubes. The power supplies provide operating voltages for each of the sections, a stable master reference voltage, and clock signals, which are the time base for the entire instrument.

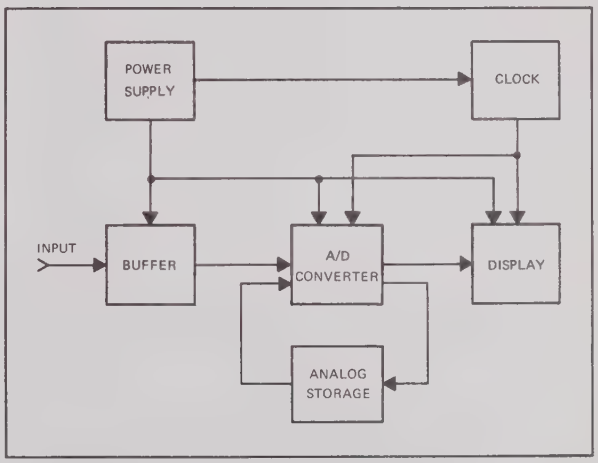



Figure 3-1. MODEL 8110A SIMPLIFIED BLOCK DIAGRAM

### 3-6. Buffer

3-7. The principal parts of the buffer are a resistive input divider, which scales the dc input voltages to 1 volt full scale; an active, switchable, two-pole input filter, providing an instrument response of either 0.25 or 1.2 seconds, which removes unwanted ac signals from the dc input; and a low-drift, high-gain amplifier having a high input impedance. Depending on the function called at the front panel, the buffer is connected in one of four modes of operation: dc voltage (VDC), kilohms (KΩ), 10 megohm (10 MΩ), or ac voltage (VAC).

3-8. When the instrument is in dc voltage mode, the buffer is connected as shown in Figure 3-2. The dc input voltage ($E_{in}$) is applied to the resistive divider. The divider

output is applied through the input filter to the buffer amplifier. The amplifier is connected as an inverting voltage follower and provides an output to the A/D converter which is the negative of the scaled-down input. The two diodes inside the feedback loop provide a threshold step, which supplies polarity information to circuitry in the A/D converter. Resistor $R_L$ is the output load resistance.

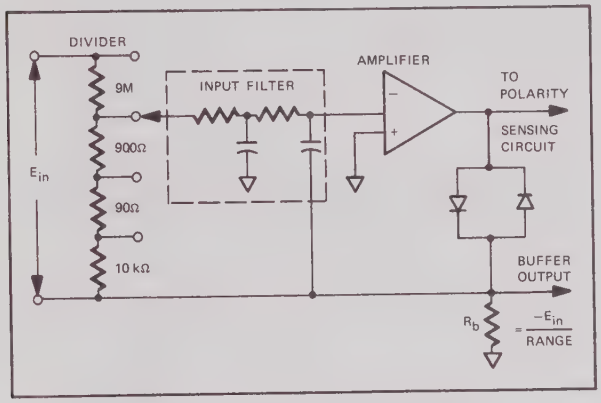



Figure 3-2. DC VOLTAGE MODE SIMPLIFIED DIAGRAM

3-9. In kilohm mode, the buffer is connected as shown in Figure 3-3. The same input divider, filter, and amplifier

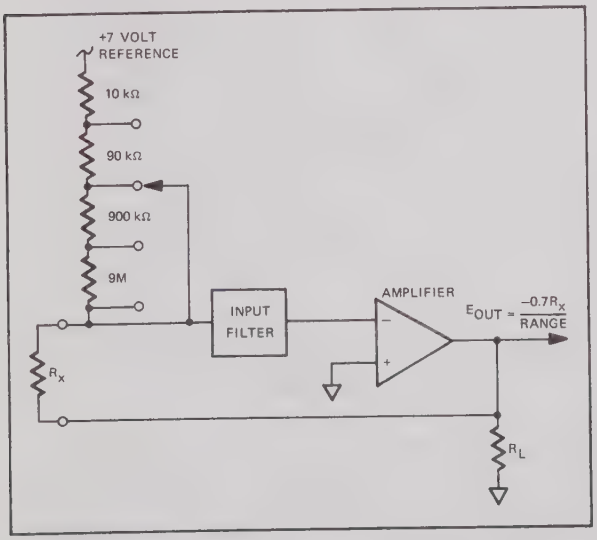



Figure 3-3. KILOHM MODE SIMPLIFIED DIAGRAM

are used, except the input divider is connected to the +7 volt reference. In this circuit arrangement, the input divider is the input resistor of an operational amplifier in which the +7 volt reference forms the input voltage and the unknown resistor ($R_x$) forms the feedback resistance. A voltage proportional to $R_x$ is applied to the A/D converter and is equivalent to –0.7 volts full scale when the proper input divider tap is selected.

3-10. In 10 megohm mode, the buffer is connected as shown in Figure 3-4. The +7 volt reference voltage is

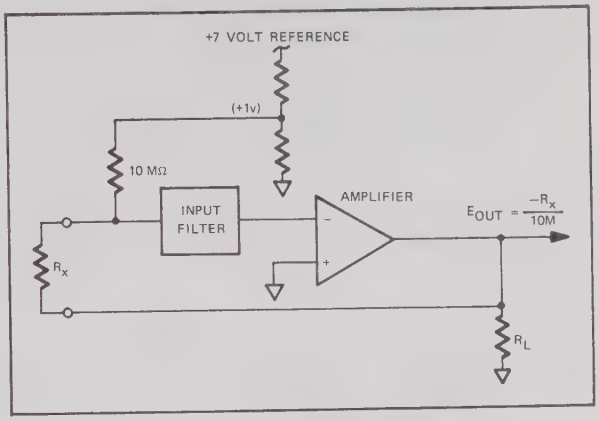



Figure 3-4. 10 MEGOHM MODE SIMPLIFIED DIAGRAM

divided down to 1 volt to limit the full-scale output of the buffer to 1 volt. In all other respects, the operation in 10 megohm mode is analagous to kilohm mode operation.

3-11. In ac voltage mode, the buffer is connected as shown in Figure 3-5. In this arrangement, the amplifier is

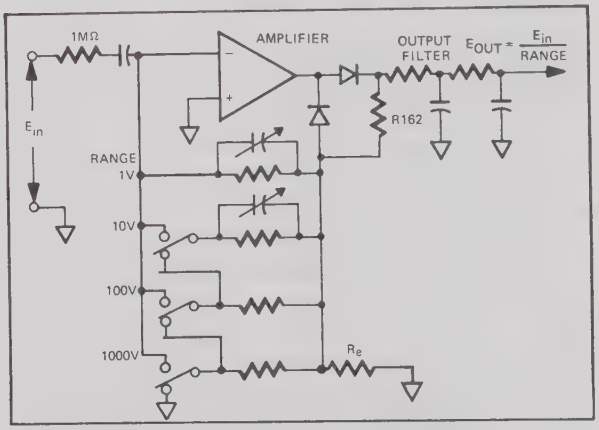



Figure 3-5. AC VOLTAGE MODE SIMPLIFIED DIAGRAM

used as an operational rectifier. A pair of rectifier diodes is placed inside a strong negative feedback loop, and a negative ac feedback signal proportional to the input voltage is developed across resistor $R_e$. A half wave rectified dc dc signal proportional to the input is developed across R162. The proper scale factor is determined by the feedback resistors, which are controlled by the front panel range switches. The positive half-cycles across R162 are filtered by a two-stage RC filter to provide a positive one volt output to the A/D converter that is scaled in terms of the rms value of a sine wave. Table 3-1 gives the full-scale buffer outputs for each of the instrument functions.

Table 3-1. BUFFER OUTPUTS

| FUNCTION | FULL-SCALE BUFFER OUTPUT (VOLTS DC) |
|---|---|
| +VDC | −1 |
| −VDC | +1 |
| KΩ | −0.7 |
| 10 MΩ | −1 |
| VAC | +1 |

## 3-12. A/D Converter

3-13. The A/D converter employs the unique recirculating-remainder ($R^2$) A/D conversion technique developed by FLUKE. A simplified diagram of the A/D converter and associated circuitry is shown in Figure 3-6. Accompanying the diagram is a chart showing the sequence of operation for an input of 0.6352 volts.

3-14. The A/D converter digitizes the input serially in four 4-millisecond time periods, with each period divided equally into digitizing and display periods, A and B. At the start of the measurement sequence, period 1A, the A to D converter samples the 0.6352 volt input. Then the analog output voltage from the X10 amplifier causes the comparator to output to the voltage controlled oscillator (VCO), and the VCO produces pulses which are entered into the counter. When the total pulse count equals the most significant digit of the input or 6, the counter stops. The ladder produces a series of six 0.1 volt steps which correspond to the counter output. The remainder of 0.0352 volts is amplified by the X10 amplifier and held in sample and hold capacitor C1. The display circuitry decodes the counter output and displays the 6 in period 1B. At the beginning of period 2, the 0.6352 volt input is disconnected from the input of the A/D converter and the 0.352 volt output of the sample and hold circuit is digitized and displayed as the new input. Successively, the remainders of 0.52 and 0.2 volts are digitized and displayed in the same manner. Although the four digits are digitized and displayed one at a time, the process proceeds at a sufficiently high rate of speed so that the display appears continuous to the eye.

3-15. The input voltage is sampled every 300 milliseconds. Since it only requires 20 milliseconds to digitize the input, a storage circuit is provided which stores a voltage representing each of the four digits on each of four capacitors. This stored information supplies the input during the remaining fourteen 20-millisecond periods, until the voltmeter is ready to sample the input voltage again.

3-16. Refer to the simplified A/D converter diagram in Figure 3-7 and assume that a +0.6352 volt signal is applied to FET switch Q16. The polarity sensing circuit turns on Q16 and turns off Q12 and Q17 in response to the positive input signal and the stage −1 signal from the ring counter. (Note: The positive input refers to the signal at the input of the A/D converter. The actual instrument input signal is negative, but is inverted by the buffer.) The input signal is thus applied to the positive input of amplifier A2. The feedback loop for A2 is closed through resistor R98, which is chosen to give an amplifier gain of 70. Thus, when the output of A2 is 7 volts, the voltage at $e_s$ will be 0.1 volts. With 0.6352 volts at the positive input, amplifier A2 will attempt to place the same voltage at the negative input of A2; however, as the output of A2 swings past 7 volts, the comparator produces an output that turns on the VCO. The VCO produces a series of pulses, which are entered into the counter. The counter output causes the ladder to place a corresponding series of 0.1 volt steps into point $e_s$. When six pulses have entered the counter, the ladder output will be 0.6 volts and the output of A2 will drop below 7 volts. At this point, the VCO stops generating pulses and the voltage at $e_s$ remains at 0.6 volts plus a remainder of 0.0352 volts which is applied to $e_s$ through R98. The resulting voltage at $e_R$ will then be exactly 0.352 volts or, in other words, ten times the remainder. The amplified remainder is applied through switch Q35 to the first sample and hold capacitor, C34.

3-17. Digitizing the 6 requires approximately 2 milliseconds or half of the first digitizing period, as shown in Figure 3-6. The 6, which is stored in the counter during the digitizing process, is then displayed by the display circuit. After approximately 2 milliseconds of display time, the display is turned off and the counter is reset to zero. Switch Q35 is then turned off, leaving capacitor C34 charged to 0.352 volts. At the same time, Q16 is switched off, removing the input from the A/D converter for the duration of the digitizing cycle, and the ring counter switches to stage 2, turning on switches Q36 and Q39. The 0.352 volts is then applied through Q36 to the input of A2 and is digitized as the new input signal. The resulting amplified remainder of 0.52 volts is stored in the second sample and hold capacitor, C35, while the 3 is digitized and displayed in the second readout tube. The process is repeated twice more, digitizing both the 5 and the 2, with the amplified remainder alternately supplied by the two sample and hold capacitors.

3-18. If the A/D converter input voltage had been negative, the polarity sensing circuit would have turned on

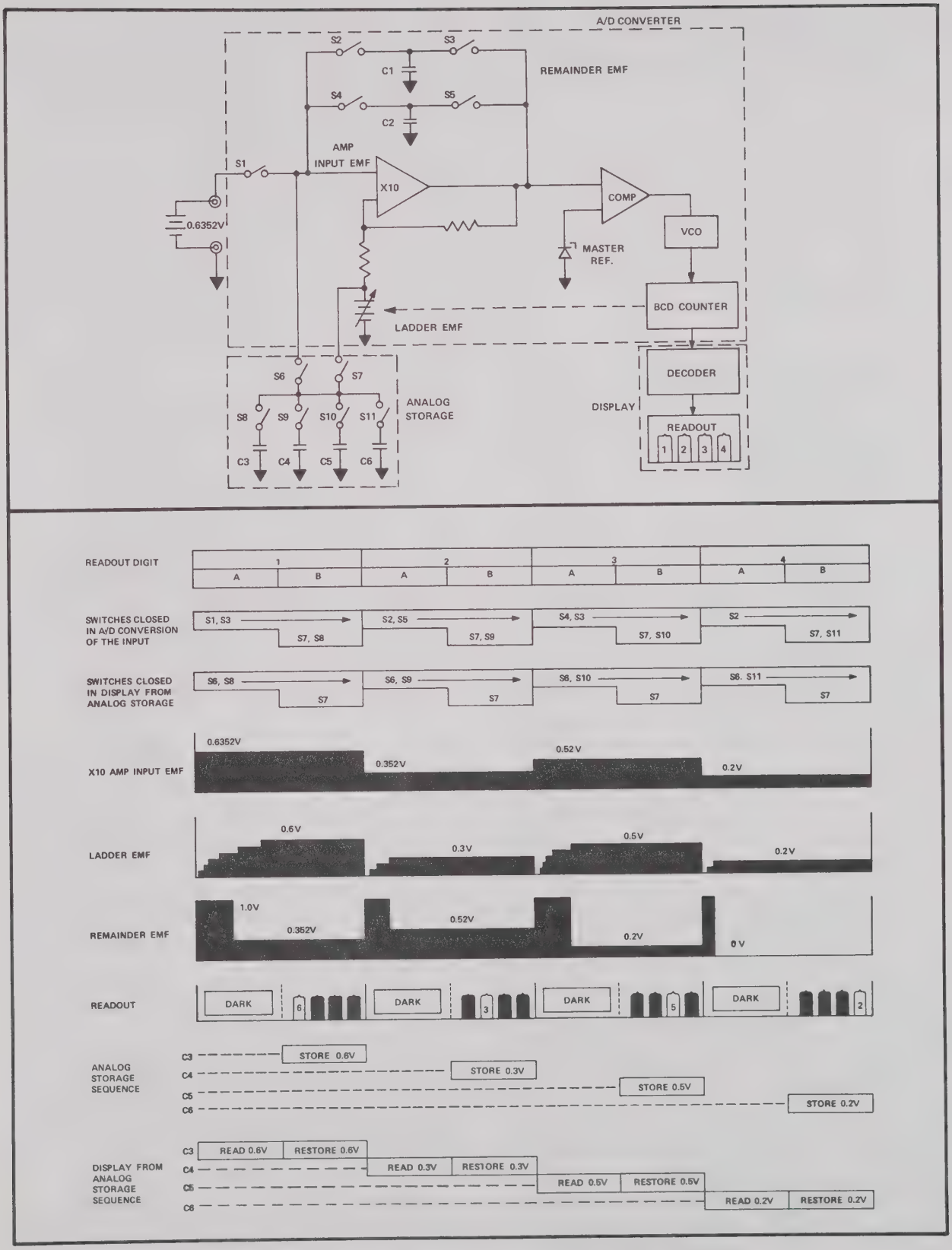



Figure 3-6. RECIRCULATING-REMAINDER A/D CONVERSION

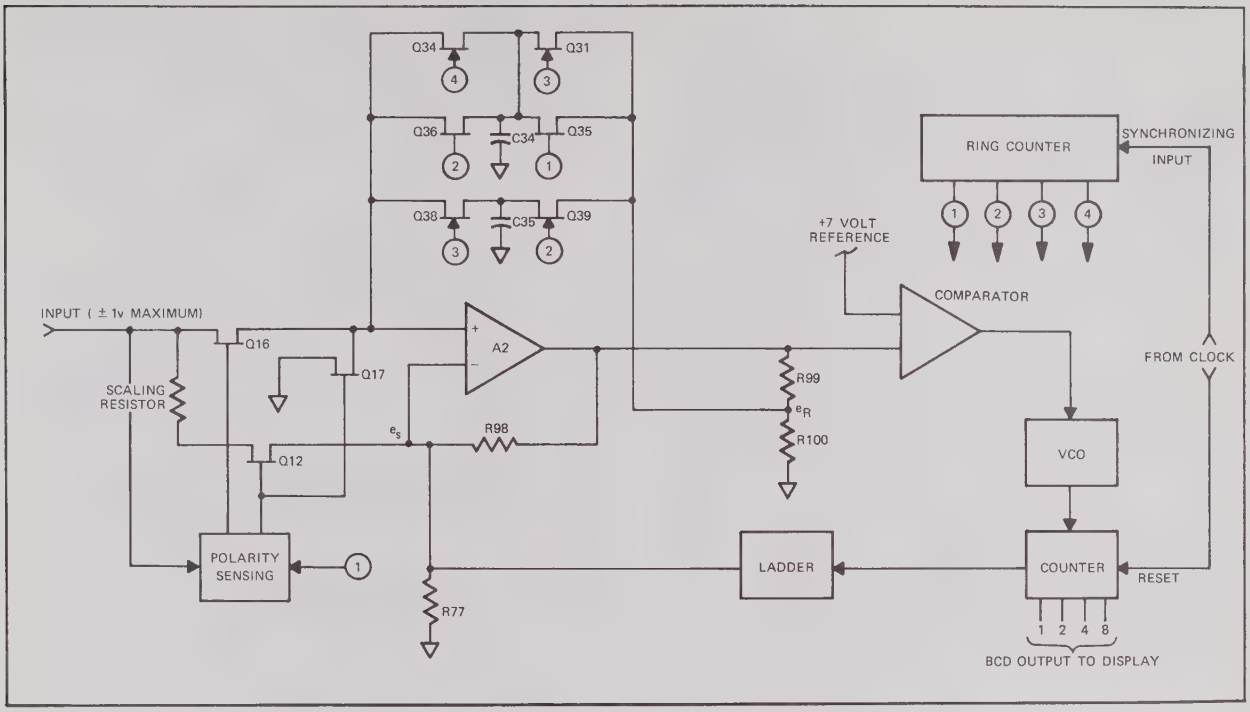



Figure 3-7. A/D CONVERTER SIMPLIFIED DIAGRAM

switch Q12 and Q17 instead of Q16 during the first period, and the voltage would have been applied to the negative input of A2, with Q17 holding the positive input of A2 at ground. With a negative input, both the ladder and resistor R98 are used as current summing resistors, since the negative input of amplifier A2 will be at virtual ground. The scaling resistor is the operational input resistance and is adjusted to set the amplifier gain to proper value. After the first digit is digitized, Q12 and Q17 are switched off and the remainder terms are digitized in the same manner as previously explained.

## 3-19. Analog Storage

3-20. A simplified diagram of the analog storage circuit is shown in Figure 3-8. This circuit accepts the 4-bit BCD output of the counter and converts it into an analog voltage which corresponds to the displayed digit. The analog voltage is applied to the storage capacitors through FET input switch Q28 during the display half of each clock cycle. Each of the four analog voltages is stored in a separate capacitor which is switched into the circuit by the ring counter at the same time that the corresponding digit is being displayed. When the measure/store multivibrator switches to the storage mode, FET output switch Q29 is turned on and the input voltage is disconnected from the input of the A/D converter. The analog voltages in the

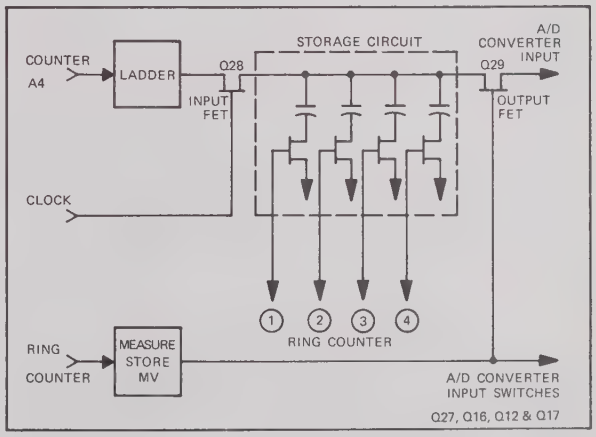



Figure 3-8. ANALOG STORAGE SIMPLIFIED DIAGRAM

storage circuit are then applied, digit by digit, to the A/D converter input. The voltages are digitized, displayed, and then re-stored in the analog storage circuit. The storage readout cycle lasts for approximately 300 milliseconds, after which time the measure/store multivibrator switches to measure mode and the A/D converter input is reconnected to the input signal. There are approximately 14 cycles of storage for every measurement cycle, which provides a continuous display that changes (input is sampled) three times per second.

## 3-21. Display

3-22. The 4-line BCD output from the A/D converter, containing the digit information, is applied to the decoder/driver. The decoder/driver provides a 10-line output, which is connected to the readout tube cathodes as shown in Figure 3-9. All readout tube cathodes are connected in

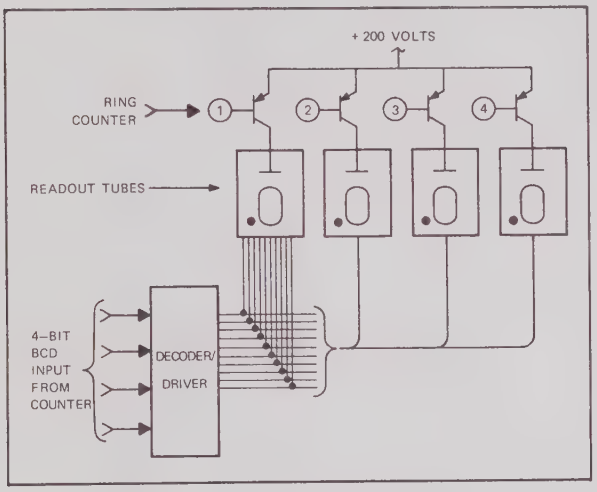



Figure 3-9. DISPLAY SECTION SIMPLIFIED DIAGRAM

parallel so that the same digit is turned on in each tube. However, only the readout tube corresponding to the proper digit will be turned on by the ring counter. Therefore, all four digits are displayed on a time-share basis using one counter and one decoder/driver. The display cycle occurs during the second half of each digitizing period, as shown in Figure 3-6, whereas digitizing in the A/D converter occurs during the first half of the period.

## 3-23. Power Supply and Clock

3-24. All operating voltages for the Model 8110A are produced by a series of regulated power supplies that derive their voltages from a −18 volt regulator (see Figure 3-10). In line operated instruments, the −18 volt regulator is supplied raw voltage by a transformer/rectifier; and in battery operated instruments, voltage is supplied by rechargeable batteries. The −18 volt regulator output is used throughout the instrument as an operating voltage and is also applied to the inverter input. The inverter provides +17 volts dc to the +15 volt regulator which, in addition to supplying instrument operating voltages, serves as source for the +7 volt reference. The inverter also provides 200 volts, which drives the readout tubes, and +5 volts to operate the integrated logic circuitry. Finally, the inverter supplies the 250 Hz clock signal.

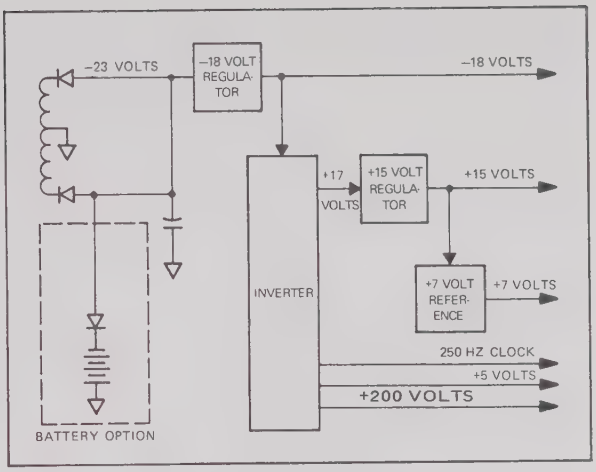



Figure 3-10. POWER SUPPLY AND CLOCK SIMPLIFIED DIAGRAM

## 3-25. CIRCUIT DESCRIPTION

## 3-26. Buffer

3-27. INPUT RANGE DIVIDER In dc voltage mode, the input binding posts are connected across a four position range divider located on the small plug-in circuit board. The 10 volt, 100 volt and 1000 volt ranges each have a calibration potentiometer which allows adjustment of the full-scale output of each position to exactly 1.000 volts dc. In kilohm mode, the bottom of the input divider (R1 on the divider board) is disconnected from the LO binding post and connected to the +7 volt reference. When so connected, the divider acts as the current determining network for ohms measurement. Selection of the proper range places the required portion of the divider in series with the +7 volt reference. In all kilohm ranges, the voltage developed across the unknown resistor is 0.7 volts at full scale. In 10 megohm mode, the bottom end of the divider is connected to divider R152, R154, which is adjusted by R153 to provide an output of 1 volt. This 1 volt output sets the current through the entire range divider to provide the proper scale factor; full scale output in 10 megohm mode is 1 volt.

3-28. INPUT FILTER The output of the range divider is applied to an active, two-pole filter consisting of resistors R27 and R28 and capacitors C10 through C13. When the FILTER switch is ON, the filter consists of R27 and C10 in the first section and R28 and C12 in the second section and provides a settling time of 1.2 seconds and noise rejection of 60 db at 60 Hz. When the FILTER switch is OFF, C11 is placed in series with C10 and C13 is placed in series with C12, thereby reducing the settling time to 0.25 second and

the noise rejection to 20 db at 60 Hz. Diodes CR11 and CR12, in conjunction with R27, protect both the filter and the buffer amplifier from excessive input voltages. In the 10 volt dc range, R27 is shorted out, since the output impedance of the range divider is 1 megohm and R27 is not needed.

3-29. BUFFER AMPLIFIER The buffer amplifier consists of transistors Q77, Q79, and Q80 and amplifier A1. The first stage amplifier is Q77, a low-noise, low-drift JFET pair operating in common-source configuration. Potentiometer R175 is the zero adjustment control, which in conjunction with R176, R177, and R193 is used to reduce the initial offset of Q77 to zero. The output of Q77 drives A1, a monolithic operational amplifier that provides most of the voltage gain. Capacitor C51 is placed around A1 to provide a smooth roll-off through unity gain. Transistor Q79 is a common base output stage which raises the output impedance of the amplifier as high as possible. To avoid degrading the high output impedance, Q79 operates into a constant current load, Q80.

3-30. In dc voltage, kilohm, and 10 megohm modes, the feedback loop for the unity gain buffer amplifier is completed through diodes CR14 and CR15 which provide a voltage step around zero to drive the polarity sensing circuit. Resistor R174 is the load resistor for the amplifier. In ac voltage mode, the buffer amplifier is connected as an operational amplifier, with R24 functioning as the input resistor. The input signal is coupled through capacitor C9 to the gate of Q77 and the negative feedback loop is completed through the range resistors, R29, R30, R31, and R32. Diodes CR14 and CR15 act as an operational rectifier in ac voltage mode. A positive, half-wave rectified dc voltage, proportional to the average value of the ac input, is developed across R162. This voltage is smoothed by a two-stage filter composed of resistors R35 and R36 and capacitors C19 and C20. Potentiometer R34 (ACV CAL) is adjusted to provide a filter output of 1 volt for a full scale input on any instrument range. Because the input capacity of Q77, together with additional stray capacities, causes an additional pole in the loop response of the ac converter, trimmer capacitors C14 and C15 are provided on the two lowest ranges to adjust the frequency response through 20 kHz. Frequency adjustment is not necessary on the upper two ranges because of the low resistance of R31 and R32.

## 3-31. A/D Converter

3-32. CLOCK The clock signal, which is the master timing signal for the A/D converter, is taken from several windings on the inverter transformer, T102. T102-2 supplies a gate control signal for the analog storage circuit. The signal at T102-10 is used to strobe the readout tubes and synchronize the ring counter. Both T102-10 and T102-8 signals are applied to NAND gate A3A to provide a delayed reset pulse for counter A4. The timing diagram for the A/D converter is shown in Figure 3-11. Note that the measurement cycle is actually one period longer than was shown in the simplified diagram of Figure 3-6. The added period is set aside at the beginning of each measurement cycle for removal of the zero offset of the A/D converter amplifier.

3-33. RING COUNTER. The five-stage ring counter consists of transistors Q19 through Q24 and associated components. The ring counter will free run at a frequency slightly less than the clock frequency. However, the clock signal forces the counter to speed up, thereby synchronizing the five counter periods with the clock. The purpose of Q24 is to prevent two pulses from entering the ring at one time. At the end of the fifth period in the measurement cycle, the ring counter supplies a synchronizing signal to the measure/store multivibrator.

3-34. POLARITY SENSING CIRCUIT . The polarity sensing circuit consists of transistors Q13, Q14, Q15, and associated components. At the beginning of the second period in every measurement cycle, Q13 is turned on by the second stage signal from the ring counter. As soon as Q13 turns on, the polarity sensing circuit responds to the voltage which appears at R40. If the instrument input voltage is negative, the voltage at R40 will be positive, transistor Q15 will conduct, and the signal at the collector of Q15 in conjunction with the signal from the measure/store multivibrator (Q25) will turn on FET switch Q16. Switch Q16 then connects the positive buffer output voltage at test point 9 (TP9) to the positive input of the A/D converter amplifier. If the instrument input is positive, Q14 will conduct and the signal at the collector of Q14 in conjunction with the signal from Q25 will turn on FET switches Q12 and Q17. The negative buffer output will then be applied through scaling resistors R50 and R51 and switch Q12 to the negative input of the A/D converter amplifier. At the same time, the positive input of the amplifier will be connected to ground through switch Q17. Resistors R186 and R187 provide a small offset correction voltage to the positive input. The polarity indicator remains on during storage cycles, since the polarity sensing circuit monitors the input signal. During storage cycles, Q12, Q16 and Q17 are held off by a signal from the measure/store multivibrator.

3-35. A/D CONVERTER AMPLIFIER The amplifier consists of dual FET Q53, operational amplifier A2, and

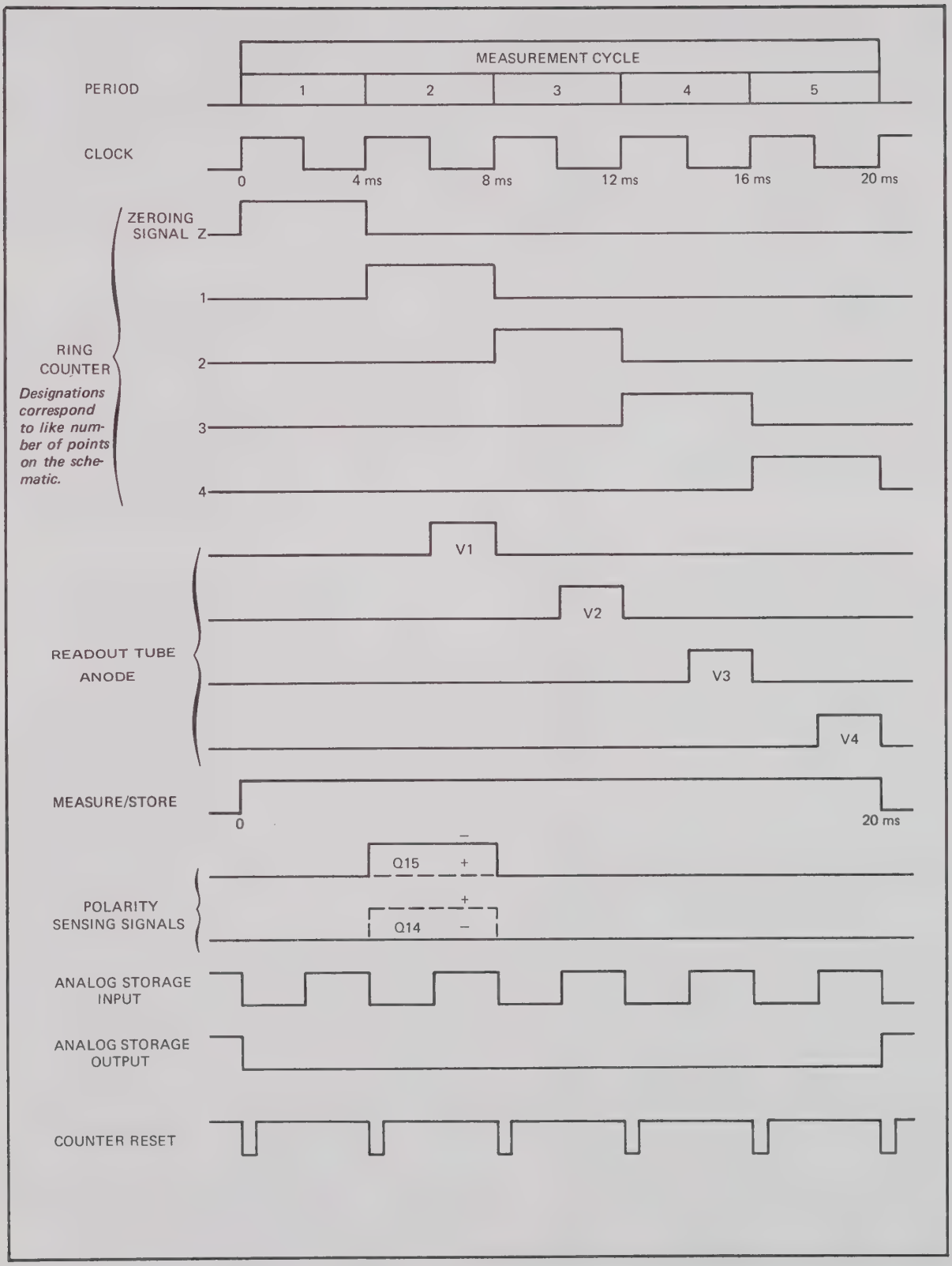



Figure 3-11. TIMING DIAGRAM

associated circuitry. Transistors Q76 and resistor R110 comprise a clamp which prevents amplifier A2 from saturating while the output is above 7 volts. Diode CR47 clamps the output of amplifier A2 on strong negative signals, such as FET switching transients. The remainder feedback loop is completed through the comparator, which consists of transistors Q86 through Q89, and through the remainder resistor R98 to the input of A2. The amplifier is able to satisfy itself through these feedback loops as long as the input does not exceed 0.1 volt. When the input exceeds 0.1 volt, the output of A2 attempts to rise above 7 volts, which causes the comparator to output to the VCO through current source Q89. During the first period or zeroing perioof of each measurement cycle, transistors Q58, Q85 and Q18 are switched on by the ring counter. Transistor Q58 connects the output of the amplifier to the zero holding capacitor C37, while Q18 connects the positive input of the amplifier to ground. This operation places the offset of Q53 across C37 and effectively removes it for the balance of the measurement cycle.

3-36. VOLTAGE CONTROLLED OSCILLATOR The VCO consists of multivibrator Q59, Q60. The VCO has no output until it is supplied current by current source Q89. When the output of A2 exceeds 7 volts, the difference is passed on to Q89 by the comparator and Q89 begins to conduct. The pulse repetition rate of the VCO is proportional to the magnitude of the driving current. The greater the current flowing into the base of Q59, the greater the number of pulses per unit time. The output of the VCO is applied to the input, pin 1, of counter A4.

3-37. COUNTER The counter is a monolithic ripple counter, having an output which corresponds to a standard 8-4-2-1 binary code. The VCO output is applied to the clock input of the counter and the reset pulse from A3A is applied to the clear input. The output of counter A4 is applied to the decoder/driver, A5, and the ladder.

3-38. LADDER The output of counter A4 is applied to the ladder switches and their drivers, transistors Q40 through Q51. The ladder switches drive two ladders. The primary ladder consists of precision resistors R79, R84, R89, R94, and R77 and produces an output that corresponds to the actual value of the digital input. The secondary ladder, which drives only the analog storage circuit, consists of resistors R75, R78, R83, R88, and R93 and produces an output that is slightly in excess of the actual value of the digital input. Each ladder comprises a 4-bit, weighted-resistor digital-to-analog converter. The analog output of the ladders is weighted in terms of seventieths of the reference voltage (+7 volts) so that they can be programmed for a 0.1 volt output for each digital bit at the input.

3-39. SAMPLE AND HOLD The sample and hold circuit consists of FET switches Q34 through Q39 and capacitors C34 and C35. During the second period of the measurement cycle, the amplified remainder is applied to C35; however, Q35 is inhibited from conducting during the first half of the period by the clock signal which is coupled through diode CR36 to its gate. During the second half of the second period, Q35 is switched on and the amplified remainder is applied to capacitor C34. During the third period, Q35 is switched off, Q36 is switched on, and the remainder is applied through FET switches Q36 and Q27 to the input of amplifier A2. At the same time, Q39 is switched on and the next remainder is applied to capacitor C35. During the fourth period, Q39 is switched off and Q37 and Q38 are switched on. The input is then supplied by the remainder voltage held on C35, while the next amplified remainder is stored on C34. In the final period of the measurement cycle, only Q34 is switched on to supply the final remainder voltage to the input of A2. Upon completion of the fifth period, the A/D converter input is connected to the instrument input voltage (if in measure mode) or the analog storage output voltage (if in storage mode) and the circulation of the new remainder proceeds in the same manner as before.

## 3-40. Analog Storage

3-41. The analog storage circuit consists of the secondary ladder (discussed in paragraph 3-38), the measure/store multivibrator, and the storage circuit.

3-42. MEASURE/STORE MULTIVIBRATOR The measure/store multivibrator, consisting of transistors Q25 and Q26, is basically a one-shot multivibrator with dual synchronizing inputs. The measurement cycle, which is approximately 20 milliseconds in duration, is coincident with conduction of Q25; and the storage cycle, which is approximately 330 milliseconds in duration, is coincident with conduction of Q26. The multivibrator is triggered at the end of each measurement cycle by the trailing (negative) edge of the signal at the collector of Q24. During the measure cycle, a signal is coupled to the polarity sensing circuit from the collector of Q25. This signal enables switch Q16 for positive signal measurement or switches Q12 and Q17 for negative signal measurement. In storage mode, this signal is not present and, consequently, the input voltage will not be connected to the A/D converter.

3-43. STORAGE CIRCUIT The storage circuit consists of FET switches Q28 through Q33 and capacitors C30 through C33. The output of the secondary ladder is sup-

plied to the appropriate storage capacitor through Q28, which is switched on during display time. The first digit is stored in C30, the second in C31, the third in C32, and the fourth in C33. When the measure/store multivibrator switches to storage mode, Q29 is switched on and the analog voltages stored in the capacitors are applied serially to the input of A2.

## 3-44. Display

3-45. The decoder/divider is a monolithic BCD-to-decimal decoder: It accepts the 4-bit BCD output of counter A4, decodes each digital word, and selects one of ten decimal output drivers. The ten driver outputs are applied to the readout tube cathodes.

3-46. The readout tubes are operated by the 200 volt power supply. During the second half of each clock period (display time), one readout tube anode is turned on by switch Q67, Q68, Q69 or Q70 and associated current source, Q71 through Q74. The switches, which are operated by the ring counter, turn on only one readout tube during each period of the measurement cycle. At the same time, the output of the decoder/driver is applied to the appropriate cathode of each of the four readout tubes and the digit is then visually presented in proper decimal position.

3-47. The overrange digit lamp, DS2, is operated by transistor Q66, which is connected in an AND configuration with gate A3C. When the output of counter A4 reaches ten, transistor Q66 conducts and turns on DS2. The function of gate A3B and transistor Q65 is to clamp the output of the VCO when counter A4 has a count of eleven during the first period of the measurement cycle (first digit) or a count of nine during any subsequent periods. The polarity sign indicator, V5, is operated by transistors Q81 and Q82 which are driven by the polarity sensing circuit.

## 3-48. Power Supply

3-49. Power of the Model 8110A is supplied either by the ac power line via power transformer T101 or by the internal rechargeable battery pack, BT1 (Option-01). The secondary of T101 is tapped for two output voltages. The higher voltage is rectified by diodes CR32 and CR33 and is used to charge the batteries through ballast lamp DS11. The ballast lamp regulates or limits battery charging current to ensure a safe level of charging current regardless of battery condition. The lower voltage is rectified by diodes CR1 and CR2 to provide operating voltage for the instrument. The voltage at filter capacitor C1 is always greater than the battery voltage during power line operation; therefore, diode CR34 is back biased, thereby preventing drain from the batteries during power line operation. The rectified power line voltage is fed through fuse F2 to a series regulator consisting of pass element Q1, driver Q2, and voltage amplifier Q3. This regulator provides –18 volts to operate the inverter and supply negative power supply voltages for the instrument. Meter M1 is placed across the pass element to provide an indication of battery condition.

3-50. The inverter is a transformer-coupled multivibrator consisting of driver transistors Q4 and Q5, transformer T102, and RC timing network C4, R6, and R7. The inverter derives its operating voltage from the –18 volt supply and is energized as soon as instrument power is applied. It operates at a frequency of approximately 250 Hz. The square wave at the primary of T102 is rectified by diodes CR5 and CR6 to provide positive voltage to operate the +15 volt regulator. The +15 volt regulator consists of pass element Q6, driver Q7, and voltage amplifier Q8. The +15 volt regulator obtains its reference from the zener diode portion of the reference amplifier Q11. In addition to supplying positive power supply voltages to operate the instrument, the +15 volt regulator also supplies the input for the +7 volt reference supply.

3-51. The +7 volt reference supply consists of compound emitter follower Q9, Q10, which is driven by reference amplifier Q11. The reference voltage is set precisely by R23 (–DC CAL control). Since the +7 volt reference must sink as well as supply current, resistor R181 is shunted across the output to draw a constant 2 milliamps from the supply. Also, diode CR10 is placed across the output of the supply to prevent current reversal during overload in the KΩ or 10 MΩ modes.

3-52. A high voltage tap in the primary of T102 supplies voltage to a halfwave voltage doubler consisting of diodes CR3 and CR45 and capacitor C6. The 200 volt output of the doubler is filtered by C65 and is used to operate the readout tubes, V1 through V4; the overrange indicator, DS2; and the polarity indicator, V5. Filtered dc voltage for operation of the integrated circuit logic as provided by diodes CR7 and CR8 and capacitor C44 in the secondary of T102.

# SECTION 4
# Maintenance

## 4-1. INTRODUCTION

4-2. This section contains information and instructions concerning preventive and corrective maintenance for the Model 8110A Digital Multimeter. Preventive maintenance consists primarily of cleaning the instrument and should be performed as often as operating conditions require. Corrective maintenance consists of troubleshooting, calibration, and performance test procedures, which are designed to aid in maintaining instrument operation within specifications. Section 3 of the instruction manual is an important supplement to the trouble-shooting section, since a thorough knowledge of instrument theory is indispensable in troubleshooting.

4-3. A calibration interval of 90 days is recommended to ensure instrument operation within the 90-day specifications stated in Section I. A calibration interval of 6 months is recommended for operation within the 6-month specifications

## 4-4. SERVICE INFORMATION

4-5. Each instrument manufactured by the John Fluke Mfg. Co., Inc. is warranted for a period of one year upon delivery to the original purchaser. Complete warranty information is contained in the Warranty page located at the front of the manual. Factory authorized calibration and repair service for all Fluke instruments is available at various world wide locations. A complete list of factory authorized service centers is located at the rear of the manual. If requested, an estimate will be provided to the customer before any repair work is begun on instruments which are beyond the warranty period.

## 4-6. TEST EQUIPMENT

4-7. The equipment recommended for performance testing, troubleshooting, and calibration of the 8110A is listed in Table 4-1 If the recommended equipment is not available, other equipment having equivalent specifications may be used.

## 4-8. GENERAL MAINTENANCE

### 4-9. Access/Disassembly

4-10. The following procedure may be used to gain access to all components except tubes; tube access procedure is given in paragraph 4-15.

a. Remove the top and bottom covers and narrow trim strips just above and below the readout tubes.

b. Remove the top guard by (1) disconnecting the spade-lug guard-connecting wire located on the right rear of the guard, (2) disconnecting the two battery leads at the printed circuit board (if

Table 4-1. TEST AND CALIBRATION EQUIPMENT

| EQUIPMENT NOMENCLATURE | RECOMMENDED EQUIPMENT | FUNCTION |
|---|---|---|
| DC Voltage Source | Fluke Model 343A DC Voltage Calibrator | Performance Tests Troubleshooting Calibration |
| AC Voltage Source | Hewlett Packard Model 745A AC Calibrator | Performance Tests Troubleshooting Calibration |
| AC Amplifier | Hewlett Packard Model 746A High Voltage Amplifier | Performance Tests Troubleshooting Calibration |
| Precision Resistors 1.0000k 10.000k 100.00k 1000.0k | General Radio Type 1440 Standard Resistor | Performance Tests Calibration |
| Autotransformer Wattmeter | General Radio Model W5MT3AW Metered Variac | Calibration |
| High Impedance or Differential DC Voltmeter | Fluke Model 885A DC Differential Voltmeter | Troubleshooting Calibration |
| Oscilloscope | Tektronix Type 545A Oscilloscope with Type 1A1 Dual Trace Plug-In | Troubleshooting |

battery option is installed), and (3) removing the four guard mounting screws located on the side rails.

**CAUTION!**

**Do not remove the six screws located on the top of the guard. These screws hold the optional battery pack in place and should not be removed until the guard is completely removed from the instrument.**

c. Remove the bottom guard by removing the four screws which hold it in place.

## 4-11. Fuse Replacement

4-12. All fuses are located inside the instrument. The line fuse is located in a fuse block attached to the inside of the rear panel and is accessible from the bottom of the instrument after removing the bottom cover. The power supply fuse is mounted in fuse clips which are attached to the printed circuit board near the power transformer. This fuse is accessible from the top of the instrument after removing the top cover. Correct values for the fuses are as follows:

| REFERENCE DESIGNATION | FUNCTION | RATING |
|---|---|---|
| F1 | Line Fuse | 115 volt operation: 1/8 ampere slowblow<br>230 volt operation: 1/16 ampere slow-blow |
| F2 | Power Supply Fuse | AGC 1/4 ampere |

## 4-13. 115/230 Volt Conversion

4-14. The 8110A may be operated from either 115 or 230 volt ac power, depending upon the connection of the power transformer (T101) primary winding. Convert the instrument from one type of power line operation to the other by the following procedure:

a. Disconnect the instrument from the power line.

b. Place the 115/230 slide switch, located at the rear of the instrument, in the position which corresponds to the desired operating voltage. The switch is accessible after removing bottom cover.

c. Ensure that the proper line fuse for the selected voltage is installed (paragraph 4-11) before operating the instrument.

## 4-15. Lamp and Tube Replacement

4-16. Ballast lamp DS11 is soldered in place on the circuit board, at the rear of the instrument, near the power transformer. It is accessible after removing the top and bottom covers. Readout tubes V1 through V4 and polarity indicator V5 are mounted in tube sockets and are located inside the black tube cover at the front of the circuit board. To gain access to V1 through V5, proceed as follows:

a. Remove the top cover and the narrow trim strip just above the readout tubes.

b. Remove the small nut and washer from the stud bolt which is located just to the left of the meter on the inside of the front panel.

c. Remove the two screws which fasten the tube cover to the PCB.

d. Pull the end of the tube cover nearest the meter away from the panel far enough to clear the stud bolt, and lift the tube cover clear of the tubes.

e. All readout tubes except the overrange indicator are mounted in tube sockets. The overrange indicator is soldered to the PCB. Solder terminals are on the underneath side of the board and are accessible after removing the bottom dust cover, trim strip, and guard chassis.

## 4-17. Switch Maintenance

4-18. The following procedures cover service and replacement of the pushbutton switches.

4-19. GENERAL

a. Remove the dust covers, trim strips, and guard chassis. See paragraph 4-9 for Guard removal instructions.

b. Set all switches to the nondepressed position.

c. If switch contacts are to be serviced, locate which of the 19 switch modules is to be disassembled (Figure 4-1) and refer to the corresponding disassembly procedure, paragraphs 4-20 through 4-22.

d. If a complete switch module is to be replaced, refer to paragraphs 4-23 and 4-24.

e. To remove pushbuttons, pry the button off by applying pressure to the rear of the button from the inside of the front panel. Note that on some instruments buttons are glued on the switch

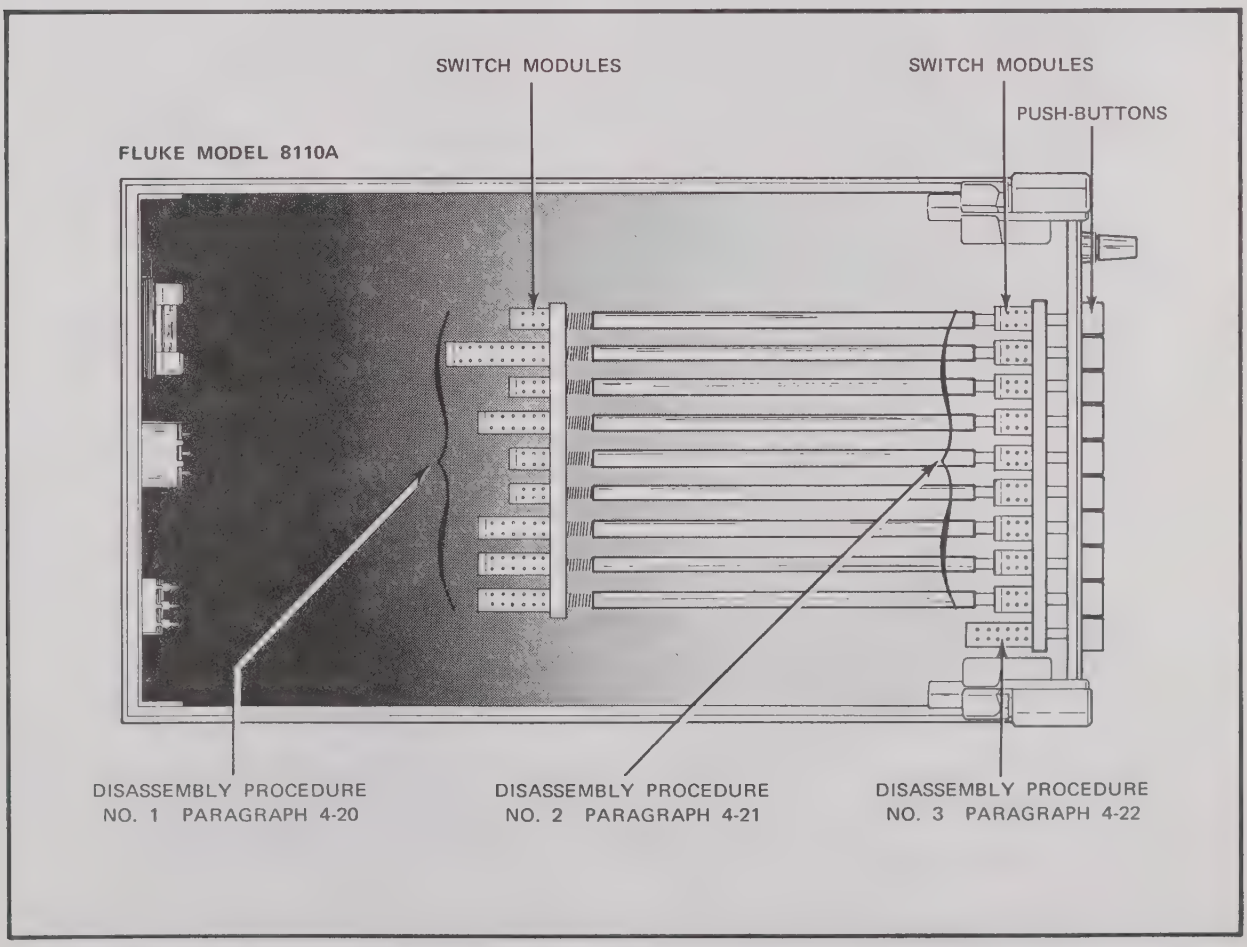



Figure 4-1. SWITCH MODULE LAYOUT AND CORRESPONDING DISASSEMBLY PROCEDURES

shaft. When replacing buttons, use a small amount of contact cement. Apply glue to shaft only.

4-20. PROCEDURE NO. 1 - DISASSEMBLY OF REAR SWITCHES (Figure 4-2)

a. Remove the extension shaft associated with the switch by depressing the switch shaft and removing the extension shaft as shown in Detail A, Figure 4-2.

b. Remove the retaining clip and spring from the switch shaft.

*NOTE!*

*The retaining clip may be re-installed on the switch shaft from either the board side or from the opposite side (dust cover side). Either method is satisfactory.*

c. Remove the switch shaft by pushing it slowly out the back of the switch module. The moveable switch contacts will spring out of their slots in the shaft as this is done (see Detail B, Figure 4-2).

CAUTION!

**Under no circumstances should attempts be made to re-form or add tension to the contacts by bending them.**

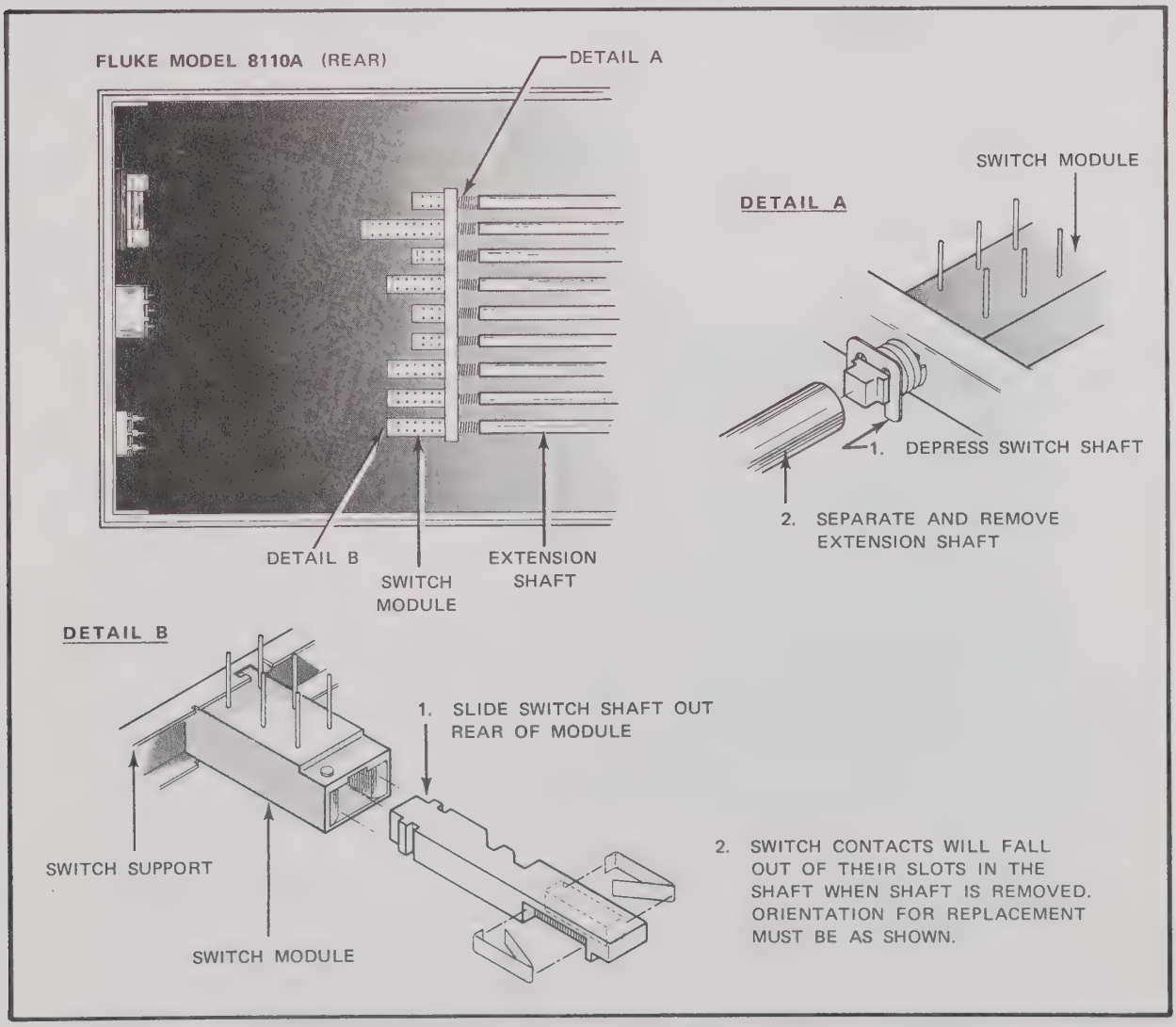

FLUKE MODEL 8110A (REAR)
DETAIL A
DETAIL B
SWITCH MODULE
EXTENSION SHAFT
DETAIL A
SWITCH MODULE
1. DEPRESS SWITCH SHAFT
2. SEPARATE AND REMOVE EXTENSION SHAFT
DETAIL B
1. SLIDE SWITCH SHAFT OUT REAR OF MODULE
SWITCH SUPPORT
SWITCH MODULE
2. SWITCH CONTACTS WILL FALL OUT OF THEIR SLOTS IN THE SHAFT WHEN SHAFT IS REMOVED. ORIENTATION FOR REPLACEMENT MUST BE AS SHOWN.

Figure 4-2. DISASSEMBLY OF REAR SWITCH MODULES

d. Inspect the switch contacts for contamination and, if necessary, clean them with a cotton swab saturated in alcohol. After cleaning, the contacts must be re-coated with a thin coat of grease: Use RYKON 2EP grease (American Oil Co.) or equivalent.

e. Assemble the switch by reversing the foregoing procedure. Exercise caution to ensure the contacts are not deformed during assembly.

4-21. PROCEDURE NO. 2 - DISASSEMBLY OF FRONT SWITCHES (EXCEPT POWER SWITCH)

a. Remove the extension shaft associated with the switch by depressing the switch shaft and removing the extension shaft as shown in Detail A, Figure 4-2.

b. Remove the pushbutton from the switch.

c. Remove the switch shaft by sliding the latch bar to the side and pushing the shaft slowly out the back of the switch module (see Detail A, Figure 4-3). Use a pointed tool to move the latch bar. The latch bar is conveniently actuated from the shaft opening at an adjacent switch, in which case the pushbutton will have to be removed from the adjacent switch shaft also. The moveable contacts will spring out of their slots in the shaft as

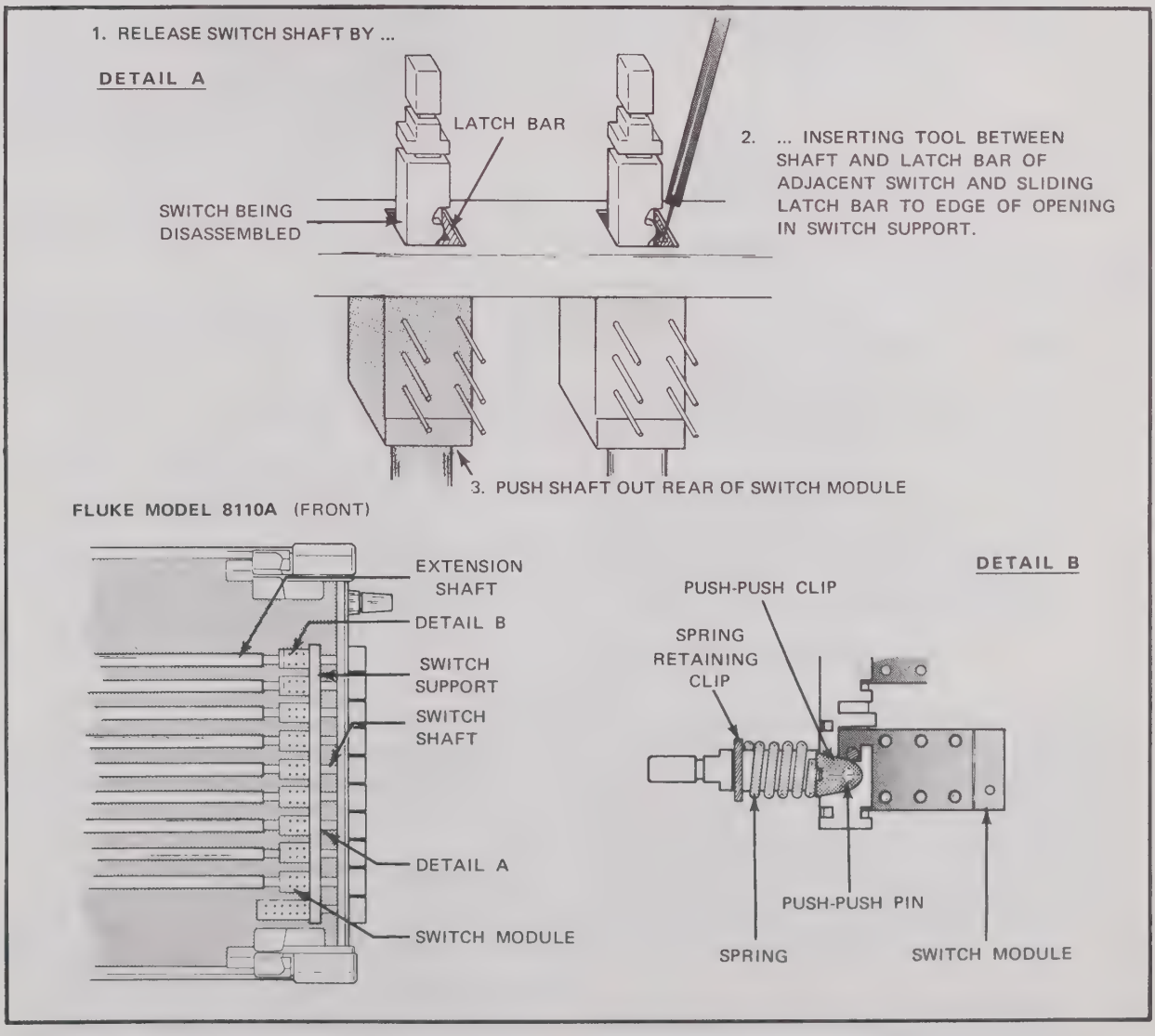



Figure 4-3. DISASSEMBLY OF FRONT SWITCH MODULES

the switch shaft is removed (see Detail B, Figure 4-2).

**CAUTION!**

**Under no circumstances should attempts be made to re-form or add tension to the contacts by bending them.**

d. Inspect the switch contacts for contamination and, if necessary, clean them with a cotton swab saturated in alcohol. After cleaning, the contacts must be re-coated with a thin coat of grease: Use RYKON 2EP grease or equivalent.

e. Assemble the switch by reversing the foregoing procedure. Exercise caution to ensure the contacts are not deformed during assembly.

*NOTE!*

*The latch bar will have to be slid to the side, as in step (c), to replace the switch shaft.*

4-22. PROCEDURE NO. 3 - DISASSEMBLY OF POWER SWITCH (Figure 4-3)

a. Remove the pushbutton from the switch.

b. Remove the spring retaining clip, the spring, the push-push clip, and the push-push pin (see Detail B Figure 4-3).

c. Remove the switch shaft by pushing it slowly out the back of the switch module. The moveable switch contacts will spring out of their slots in the shaft as this is done (see Detail B, Figure 4-2).

**CAUTION!**

**Under no circumstances should attempts be made to re-form or add tension to the contacts by bending them.**

d. Inspect the switch contacts for contamination and, if necessary, clean them with a cotton swab saturated in alcohol. After cleaning, the contacts must be re-coated with a thin coat of grease: Use RYKON 2EP or equivalent.

e. Assemble the switch by reversing the foregoing procedure. Exercise caution to ensure the contacts are not deformed during assembly.

4-23. SWITCH MODULE REPLACEMENT – REAR SWITCHES (Figure 4-4).

a. Unsolder all wires and components connected to terminals of switch modules.

b. Desolder entire rear switch set by removing the solder from all switch pins on component side of main PCB.

**CAUTION!**

**Use a desoldering tool and exercise extreme caution to avoid lifting land patterns or otherwise damaging the PCB.**

c. Remove switch set from PCB.

d. Bend up the locking tab (on switch support) which holds the defective switch module in position. Remove and descard defective switch module. See Detail A, Figure 4-4.

e. Install new switch module by reversing foregoing procedure.

4-24. SWITCH MODULE REPLACEMENT – FRONT SWITCHES (Figure 4-4).

a. Remove all front panel pushbuttons.

b. Unsolder all wires connected to terminals of switch modules.

c. Desolder entire front switch set by removing the solder from all switch pins on component side of main PCB.

**CAUTION!**

**Use a desoldering tool and exercise extreme caution to avoid lifting land patterns or otherwise damaging PCB.**

d. Remove switch set from PCB.

e. Remove defective switch module shaft and contacts according to the procedure given in paragraphs 4-21 and 4-22.

f. Bend up locking tab (on switch support) which holds defective switch module in position. Re-

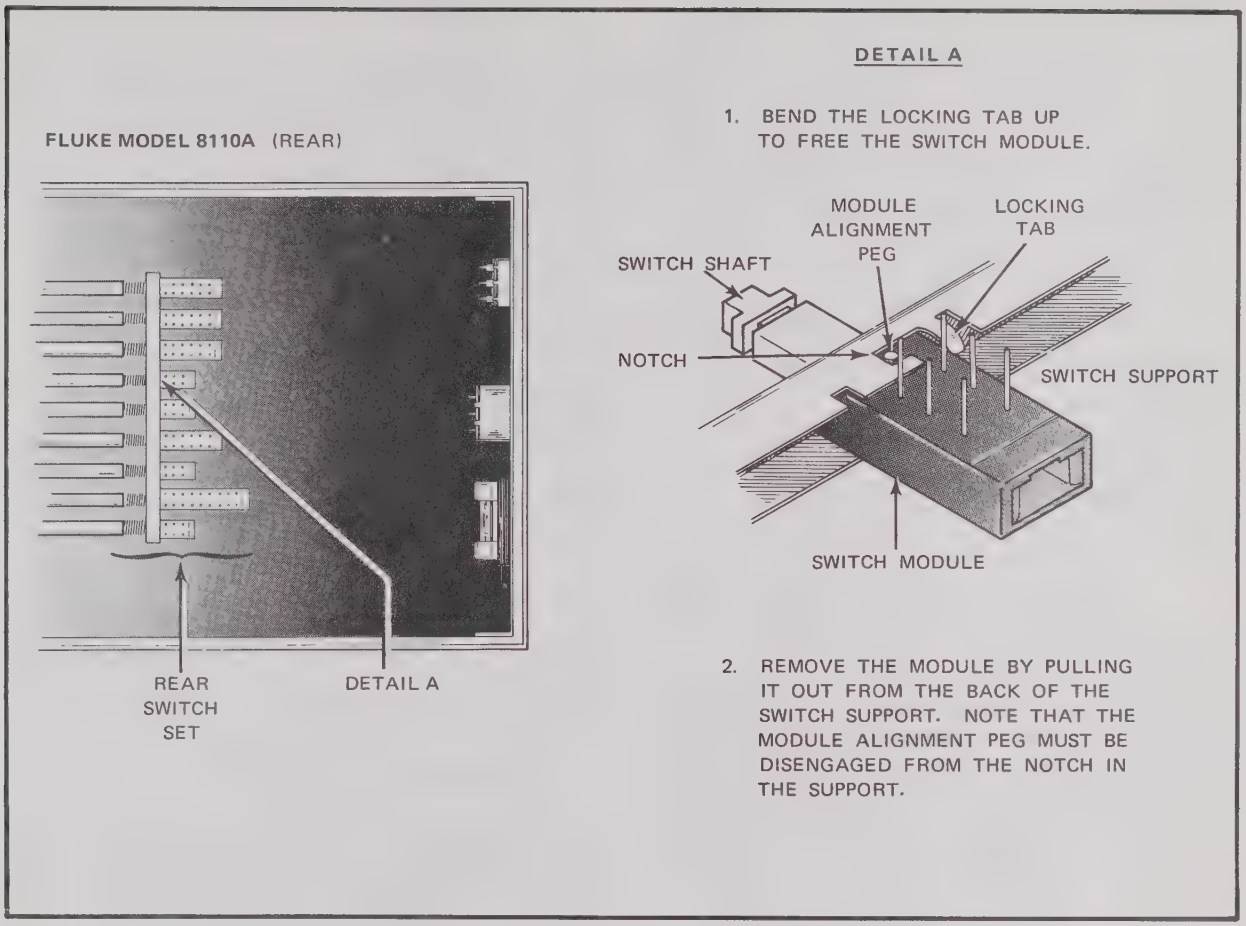

FLUKE MODEL 8110A (REAR)
REAR SWITCH SET
DETAIL A
DETAIL A
1. BEND THE LOCKING TAB UP TO FREE THE SWITCH MODULE.
MODULE ALIGNMENT PEG
LOCKING TAB
SWITCH SHAFT
NOTCH
SWITCH SUPPORT
SWITCH MODULE
2. REMOVE THE MODULE BY PULLING IT OUT FROM THE BACK OF THE SWITCH SUPPORT. NOTE THAT THE MODULE ALIGNMENT PEG MUST BE DISENGAGED FROM THE NOTCH IN THE SUPPORT.

Figure 4-4. MODULE REPLACEMENT – REAR SWITCH SET

move and discard defective switch module. See Detail A, Figure 4-4.

g. Install new switch module by reversing foregoing procedure.

## 4-25. Cleaning

4-26. The instrument should be cleaned periodically to remove dust, grease, and other contamination. The following procedure should be adhered to when cleaning the instrument:

a. Remove loose contamination with low-pressure, clean, dry air. Pay particular attention to the front panel binding posts and binding post wiring.

b. The front panel and exterior surfaces may be cleaned with anhydrous ethyl alcohol or a soft cloth dampened in a mild solution of detergent and water.

**CAUTION!**

**Do not use aromatic hydrocarbons or chlorinated solvents on the front panel, because they will react with the Lexan binding posts.**

## 4-27. PERFORMANCE TESTS

4-28. The following tests are intended for use in performance testing of the 8110A. The tests compare the instrument performance to the accuracy specifications and are especially suited to acceptance testing of new instruments. Tests should be conducted under the following conditions: ambient temperature 25°C ±5°C, relative humidity less than 70%.

*NOTE!*

*Tolerances and test limits for performance tests are derived from the 90-day instrument specifications.*

## 4-29. DC Voltage Test

4-30. In the following procedure, dc voltages are applied to the instrument at 100% of full scale on the 10, 100, and 1000 volt ranges and at 10% and 100% of full-scale on the 1 volt range. A dc voltage source equivalent to the one shown in Table 4-1 is required for this test.

a. Connect the 8110A to the ac line.

b. Set the 8110A controls as follows:

| | |
|---|---|
| POWER | ON |
| Function | VDC |
| RANGE | As Required |
| FILTER | ON |

c. Apply each of the input voltages shown in Table 4-2, in turn, to the INPUT terminals of the 8110A. The 8110A readout should be as indicated.

Table 4-2. DC VOLTAGE TEST REQUIREMENTS.

| INPUT (VOLTS DC) | MODEL 8110A | |
|---|---|---|
| | RANGE | READOUT LIMITS |
| +1000 | 1000 | +999.8 to +1000.2 |
| +100 | 100 | +99.98 to 100.02 |
| +10 | 10 | +9.998 to 10.002 |
| +1.0001 | 1 | +.9999 to +1.0003 |
| +0.0999 | 1 | +.0998 to +.1000 |
| +0.1000 | 1 | +.0999 to +.1001 |

d. Repeat step (c) with negative input voltages. The 8110A readout should be the same as for positive inputs, except that the polarity indication should be negative (–).

## 4-31. AC Voltage Test

4-32. In this test, full-scale voltages are applied to the instrument input at 100% of full scale on the 1, 10, and 100 volt ranges and 10% of full scale on the 1000 volt range. The 1 and 10 volt ranges are checked at 1 kHz, 10 kHz, and 20 kHz and the 100 and 1000 volt ranges are checked at 1 kHz only. An ac voltage source equivalent to the one shown in Table 4-1 is required for this test.

a. Connect the 8110A to the ac line.

b. Set the 8110A controls as follows:

| | |
|---|---|
| POWER | ON |
| Function | VAC |
| RANGE | As Required |
| FILTER | ON |

c. Apply the ac test signals shown in Table 4-3 to the 8110A INPUT terminals. The readout should be as indicated.

Table 4-3. AC VOLTAGE TEST REQUIREMENTS.

| INPUT | | MODEL 8110A | |
|---|---|---|---|
| FREQUENCY (KHZ) | RMS VOLTS | RANGE | READOUT LIMITS |
| 1 | 1 | 1 | .9975 to 1.0025 |
| 1 | 10 | 10 | 9.975 to 10.025 |
| 1 | 100 | 100 | 99.75 to 100.25 |
| 1 | 100 | 1000 | 099.3 to 100.7 |
| 10 | 1 | 1 | .9975 to 1.0025 |
| 10 | 1 | 1 | .9975 to 10.025 |
| 20 | 1 | 1 | .9940 to 1.0060 |
| 20 | 10 | 10 | 9.940 to 10.060 |

## 4-33. Ohms Test.

4-34. The ohmmeter section of the instrument is checked by measuring standard resistors, whose values correspond to full scale readings on each ohms range. Standard resistors equivalent to those given in Table 4-1 should be used.

a. Connect the 8110A to the ac line.

b. Set the 8110A controls as follows:

| | |
|---|---|
| POWER | ON |
| Function | As required |
| RANGE | As required |
| FILTER | ON |

c. Connect each of the standard resistors shown in Table 4-4, in turn, to the INPUT terminals of the 8110A (use short, low-resistance connecting leads). Set the RANGE and function switches as required. The 8110A readout should be as indicated.

## 4-35. TROUBLESHOOTING

4-36. This section contains information selected to assist in troubleshooting the 8110A. Before attempting to troubleshoot the instrument, however, it should be verified that the trouble is actually in the instrument and is not caused by faulty external equipments or improper control

Table 4-4. OHMS TEST REQUIREMENTS.

| STANDARD | MODEL 8110A | | |
|---|---|---|---|
| RESISTANCE | FUNCTION | RANGE | READOUT LIMITS |
| 1.0000k | KΩ | 1 | .9997 to 1.0003 |
| 10.000k | KΩ | 10 | 9.997 to 10.003 |
| 100.00k | KΩ | 100 | 99.97 to 100.03 |
| 1000.0k | KΩ | 1000 | 999.7 to 1000.3 |
| 10 MΩ | 10 MΩ | – – | 9.994 to 10.006 |

settings. The performance tests (paragraph 4-29) are suggested as a first step in troubleshooting, since they may help to localize the trouble to a particular section of the instrument. If they fail to localize the trouble, the following individual tests may be helpful. Figure 4-5 shows location of circuit areas and test points on the PCB and Figure 4-6 shows pin connections for integrated circuits used in the instrument.

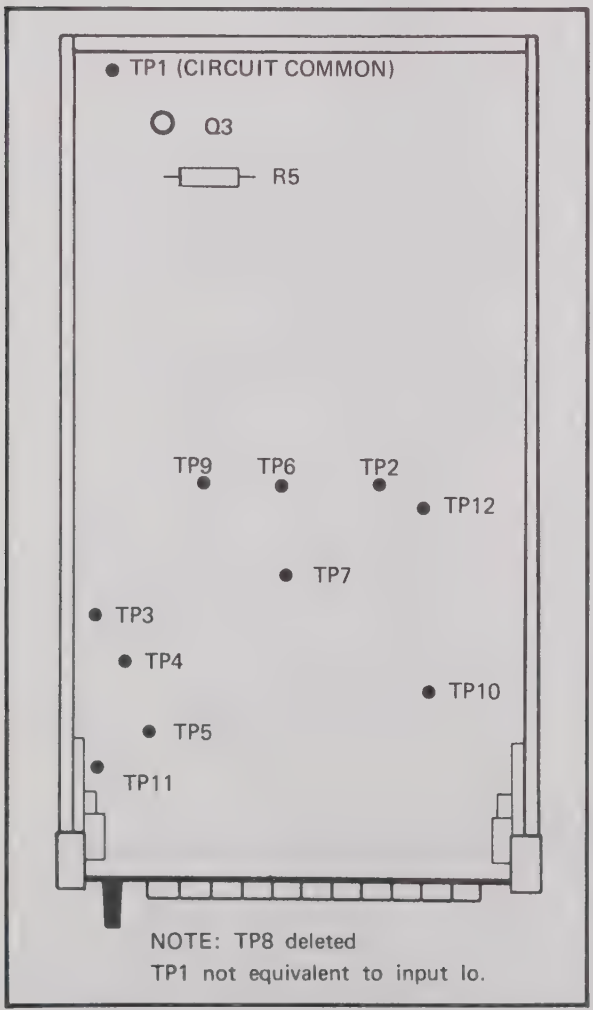



Figure 4-5. LOCATION OF CIRCUIT AREAS AND TEST POINTS ON PCB.

## 4-37. Power Consumption

4-38. This test verifies proper power consumption by the instrument.

a. Connect the 8110A through an ammeter to the ac line.

b. Press the POWER-ON switch and observe the reading on the ammeter. With only the POWER-ON switch depressed, the ammeter should indicate 42 ±4 milliamps for an instrument without batteries or 80 ±10 milliamps for an instrument with batteries.

## 4-39. Power Supply

4-40. Supply levels are referenced in such manner that unless all output levels are correct, most levels will be incorrect. This occurs because the –18 volt aupply is referenced to the +15 volt supply, which is in turn referenced to the +7 volt supply. If the –18 volt supply is high, the +15 volt and the +200 volt supplies will also be high. If the –18 volt, +15 volt, or +7 volt supply is low, all supply output voltages will be low.

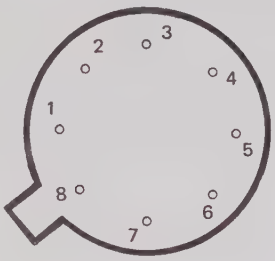
4-41. To measure the output voltages, use a voltmeter accurate to at least ±0.025% and proceed as follows:

a. Set the function, RANGE, and FILTER switches to any position.

b. Connect the voltmeter common to 8110A common (TP1) and measure the voltages shown in Table 4-5. Voltages should be as indicated.

Table 4-5. POWER SUPPLY VOLTAGE REQUIREMENTS

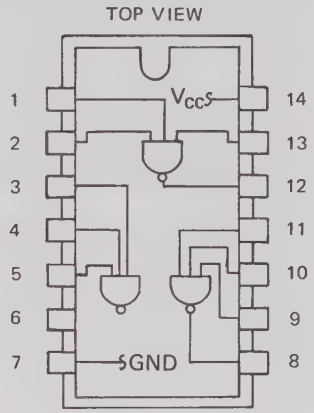
| VOLTAGE TEST POINT | NOMINAL | LIMITS |
|---|---|---|
| Either terminal of fuse F2 | –23<br>–24 | Battery Operation:<br>–19 to –24<br>Line Operation:<br>–24 Minimum |
| Collector (case of Q1) | –18 | –17.5 to –18.5 |
| +Terminal of C5 | +17 | +16.5 to +17.5 |
| +Terminal of C7 | +15 | +14.5 to +15.5 |
| +Terminal of C8 | +7 | +6.993 to +7.007 |
| +Terminal of C44 | +5 | +4.5 to +5.5 |
| +Terminal of C65 | +200 | +185 to +205 |



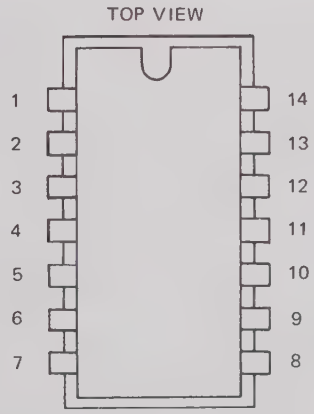

Bottom View

1. Compensation
2. Input (–)
3. Input (+)
4. V (+) (connected to case)
5. Balance
6. Output
7. V (+)
8. Compensation

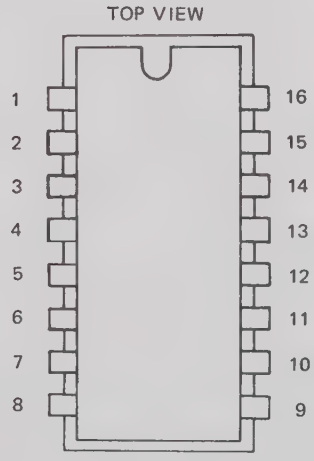
Amplifier A1 (Buffer) and A2 (A/D Converter)




3-Input NAND Gate - A1




Divide-by-Sixteen Binary Counter - A4




Decoder Driver - A5

Figure 4-6. INTEGRATED CIRCUIT PIN ORIENTATION

4-42. The following procedures can be used to isolate which supply output is low; either procedure makes the –18 volt supply independent of the other supplies for its reference. Disconnect the +15 volt end of resistor R5 and connect it to a stable external +15 volt source, or disconnect R5 from the base of Q3 and connect a 1330Ω ±1% resistor from the base of Q3 to signal ground. Location of R5 and Q3 is shown in Figure 4-5.

## 4-43. Buffer

4-44. In 1 volt dc range, the voltage between INPUT LO and signal ground (TP1) should very nearly equal the input voltage between INPUT HI and LO. At full range (−1.1999 or +1.1999 volts) the deviation should be less than 60 microvolts; at zero volts input, deviation should be less than 10 microvolts.

4-45. When measuring buffer performance, it should be noted that the INPUT LO terminal is not 8110A signal ground, as shown in Figure 4-7. This circuit may become

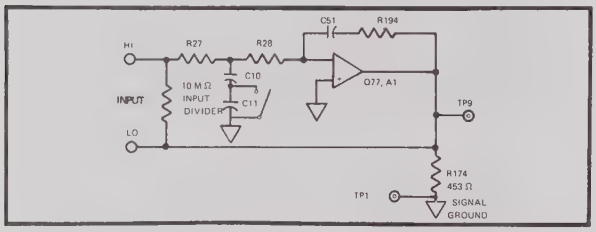



Figure 4-7. INPUT BUFFER CONFIGURATION - 1 VDC RANGE.

unstable and oscillate if a large capacitance (500pf or more) is placed across R174. To avoid this problem, it is recommended that test equipment ground be connected to INPUT LO instead of TP1 when the 8110A is measuring dc volts. In ac voltage mode, INPUT LO and signal common are equivalent.

4-46. To check the buffer in both ac and dc voltage modes, proceed as follows:

a. Set the 8110A controls as follows:

| | |
|---|---|
| POWER | ON |
| Function | VDC |
| RANGE | 1 |
| FILTER | ON |

b. Connect +1.0000 volts dc to the INPUT terminals.

c. Connect a high impedance voltmeter between instrument common (TP1) and TP9. The voltmeter should indicate −1.0000 ±0.0003 volts dc.

d. Disconnect the voltmeter high lead from TP9 and connect it to the positive (+) terminal of capacitor C18.

e. Press the VAC function switch and connect a 1.0000 volt, 1 kHz signal to the instrument INPUT terminals. The voltmeter should indicate 1.0000 ±0.0025 volts dc. If the A/D converter and display sections of the 8110A are working, the 8110A readout should correspond to the voltmeter indication.

## 4-47. A/D Converter

4-48. It is convenient to use VAC mode to check the A/D converter and display circuitry, because in this mode the INPUT LO terminal and 8110A circuit common are equivalent, as shown in Figure 4-8. The ac input signal is

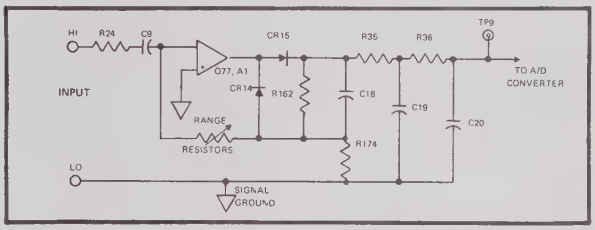



Figure 4-8. BUFFER CIRCUIT ARRANGEMENT - VAC MODE.

connected between INPUT HI and LO. If buffer problems are suspected, however, the buffer can be bypassed by connecting a low impedance (<<820k) dc source of zero to +1.1999 volts dc between INPUT LO and TP9, (Figure 4-9). The resulting readout should correspond to the A/D converter input.

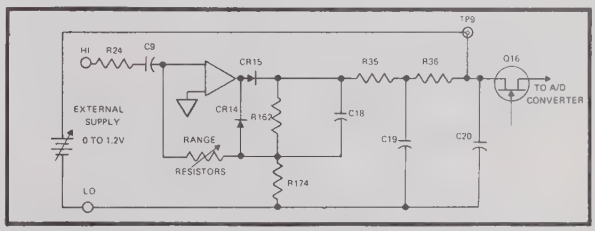



Figure 4-9. DIAGRAM OF INPUT BUFFER, VAC MODE, WITH EXTERNAL DC SIGNAL APPLIED DIRECTLY TO A/D CONVERTER.

## 4-49. 300 MS Sample Rate Suppression

4-50. The A/D converter samples the input at a fixed rate of once each 300 milliseconds. The sampled reading is then stored on capacitors C30 through C33 and is read out of storage repeatedly until the next sample is taken. The storage mode can be eliminated for test purposes by installing a jumper between TP4 and TP5. This will force the A/D converter to sample the input during period 1 of every measurement cycle, i.e., once each 20 milliseconds.

## 4-51. Auto-Zero Suppression

4-52. Amplifier A2 in the A/D converter is zeroed automatically by circuitry consisting of Q58, R180, and C37. Some failures in the converter may cause the auto-zero circuit to overcompensate and mask the trouble. To disable the auto-zero circuit, connect a jumper between TP6 and TP7. A few digits offset will be present in the readout and it will stay at zero for several digits of input on one polarity, but when the input is raised the output should follow properly.

## 4-53. Ring Counter

4-54. The signal at TP3 (Figures 4-10 and 4-11) is convenient for evaluation of the ring counter. The signals at the collectors of Q20 through Q24 are identical, but are displaced in time.

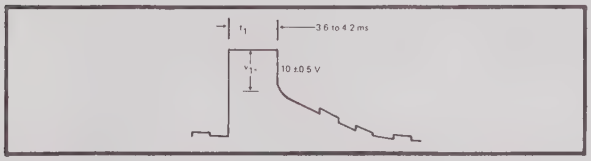



Figure 4-10. RING COUNTER SIGNAL - TP3 - CORRECT WAVEFORM.

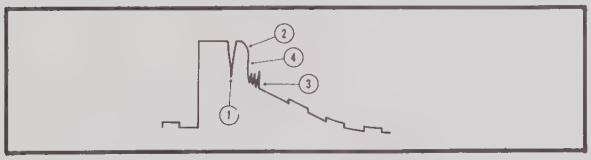



Figure 4-11. RING COUNTER SIGNAL - TP3 - MARGINAL WAVEFORM CONDITIONS.

a. In the waveform shown in Figure 4-10, $t_1$ should be 3.8 to 4.2 milliseconds. If $t_1$ is not correct, check clock signal duration. It should be 4 ±0.2 milliseconds duration.

b. The trailing edge of the signal at TP3 should be a 10 ±0.5 volt step. Factors which determine this step amplitude are repetition rate and the values of C26 and R56.

c. Marginal signal conditions are shown in Figure 4-11 and are described as follows:

1. Spike in center indicates near minimum pulse-repetition rate. Sync bias level, controlled by R61, and synchronizing signal amplitude affect center spike.
2. Trailing edge droop is mainly a function of Q19 gain: $H_{FE}$ should be greater than 100 at 1 milliamp, 0.5 volts. Droop occurs at maximum pulse repetition rate.
3. Spikes following the pulse occur if the ring counter is near an oscillation condition: Check capacitor C57.
4. Trailing edge switching time should be between 2 and 15 microseconds. Switching time is a function of the transistor and the synchronizing signal. Fall times as long as 40 microseconds have been observed when sync bias is incorrect.

d. The ring is subject to failure if the output lines are loaded by a faulty transistor, such as Q65, Q30, Q34, or any other device connected to the ring output lines. This type of failure causes the ring to oscillate at random intervals. To isolate ring problems, connect TP11 to the +15 volt supply and check that each output line is between −17 and −18 volts. Remove the +15 volt connection from TP11 and check that each collector saturates to within −0.3 volts of signal ground when the corresponding transistor turns on. Test jumpers are provided at ring positions 1, 2, 3 and 4, and can be cut to isolate loading problems in the ring.

e. The ring counter synchronizing signal, TP11, should appear as shown in Figure 4-12.

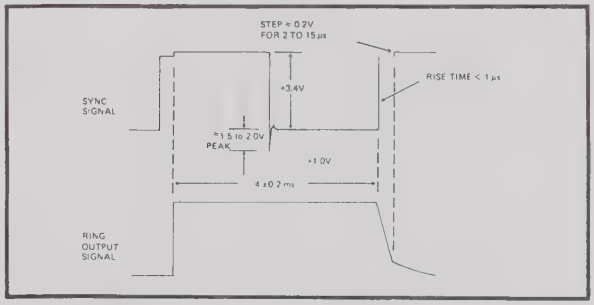



Figure 4-12. RING COUNTER - SYNC SIGNAL.

## 4-55. Measure/Store Multivibrator

4-56. Waveforms associated with the measure/store multivibrator are shown in Figure 4-13.

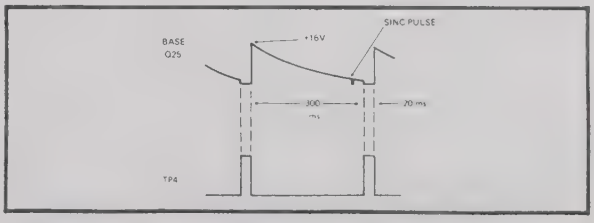



Figure 4-13. MULTIVIBRATOR WAVEFORMS.

## 4-57. Linearity

a. Set the 8110A controls as follows:

| | |
|---|---|
| Function | VDC |
| RANGE | 1 |
| FILTER | OFF |

b. Apply each of the following voltages, in turn, to the INPUT terminals. The instrument readout should be as indicated.

*NOTE!*

*The readout limits apply only to instruments that have just been calibrated.*

| INPUT (Volts DC) | MODEL 8110A READOUT LIMITS |
|---|---|
| −1.1999 | −1.1998 to −1.2000 |
| −1.0999 | −1.0998 to −1.1000 |
| −0.9999 | − .9998 to −1.0000 |
| −0.8999 | − .8998 to − .9000 |
| −0.7999 | − .7998 to − .8000 |
| −0.6999 | − .6998 to − .7000 |
| −0.5999 | − .5998 to − .6000 |
| −0.4999 | − .4998 to − .5000 |
| −0.3999 | − .3998 to − .4000 |
| −0.2999 | − .2998 to − .3000 |
| −0.1999 | − .1998 to − .2000 |
| −0.0999 | − .0998 to − .1000 |

c. If voltages are not correct, the ladder resistors should be checked for proper value.

## 4-58. Waveforms

4-59. In the following test, a dc test voltage is applied to the instrument and the main signal waveforms are examined, using an oscilloscope.

a. Set the 8100A controls as follows:

| | |
|---|---|
| POWER | ON |
| Function | VDC |
| RANGE | 1 |
| FILTER | ON |

b. Apply any stable dc voltage, within the range of the instrument, to the INPUT terminals.

c. Connect the oscilloscope between each of the test points shown in Table 4-6 and instrument common (TP1 or TP5), using ac coupling; set the oscilloscope controls as shown. A stylized version of the desired signal is shown on the main schematic diagram. Note that the A/D converter amplifier and VCO waveforms will vary, depending on input voltage value.

Table 4-6. SIGNAL LOCATIONS AND OSCILLOSCOPE SETTINGS FOR WAVEFORM CHECK.

| | TEST POINT | OSCILLOSCOPE | |
|---|---|---|---|
| | | VERTICAL SENSITIVITY | SWEEP SPEED |
| Clock | Junction of R53 and R54 | 1v/cm | 0.5 ms/cm |
| Ring Counter | TP3 | 10v/cm | 5 ms/cm |
| A/D Converter* Amplifier Output | TP2 | 5v/cm | 2 ms/cm |
| VCO | Collector of Q60 | 2v/cm | 2 ms/cm |
| Q35 Gate | Gate of Q35 | 10v/cm | 5 ms/cm |
| Counter Reset | Pin 2 of A4 | 2v/cm | 1 ms/cm |

* Waveform will be slightly different every fifteenth reading.

## 4-60. CALIBRATION

4-61. Equipment required for calibration is given in Table 4-1. Calibration should be performed under the following test conditions; ambient temperature 25°C +5°C, realtive humidity less than 70%. Adjustment locations are silk-screened on the bottom guard cover.

## 4-62. Preliminary

a. Connect the 8110A to an autotransformer adjusted for 115 volts.

b. Set 8110A FUNCTION to VDC and RANGE to 1000 volts.

c. Attach all covers and allow the 8110A to warm up for at least 1 hour.

## 4-63. Zero Adjustment

a. Set the 8110A to the 1000 volt dc range and short the input terminals.

b. Remove the bottom dust cover.

c. Connect a dc differential voltmeter between TP1 and the LO INPUT terminal, with common lead connected to INPUT LO and high lead connected to TP1.

d. Adjust the ZERO control (R175) for zero volts dc (±10 uV). If unable to obtain zero by adjusting R175, refer to the detailed procedure given in Figure 4-14.

g. Set the 8110A to the 100 volt range.

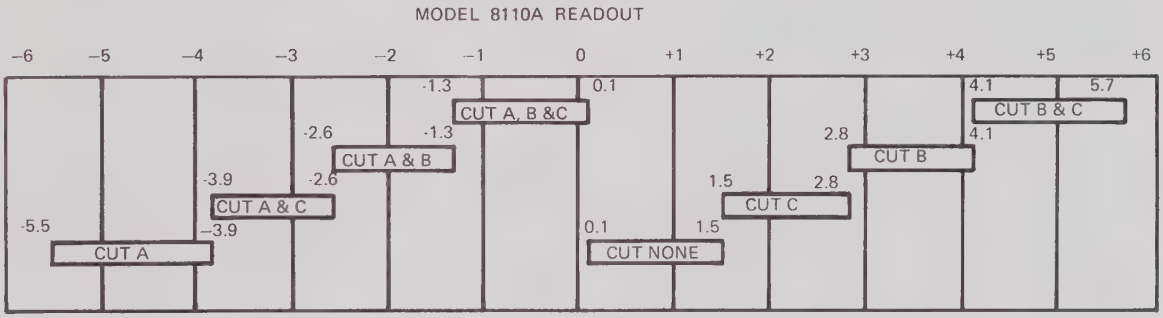
h. Apply −100.000 volts dc to the INPUT terminals.

i. Adjust the 100V CAL control (R4) for the same value measured in step (c) (±10 uV).

j. Set the 8110A to the 1000 volt range.

k. Apply −1000.00 volts dc to the INPUT terminals.

l. Set the 1KV CAL control (R2) for the same value measured in step (c) (+10 uV). Allow time for the 8110A and the dc voltage source to settle before finalizing the adjustment.




1. Connect jumpers A, B and C. Jumpers are identified on the PCB and on the schematic.
2. Set FUNCTION to VDC, RANGE to 1000, and FILTER to ON.
3. Turn ZERO adjust (R175) fully counterclockwise.
4. Note the readout and polarity indication and determine from the above chart which jumpers to cut.
5. Adjust ZERO for a readout of 000.0.

Figure 4-14. ZERO ADJUSTMENT PROCEDURE WHEN JUMPERS ASSOCIATED WITH Q77 MUST BE CHANGED.

## 4-64. Input Divider Adjustment

a. Set the 8110A to the 1 volt dc range.

b. Apply −1.00000 volts dc to the INPUT terminals.

c. Record buffer output, measured between TP1 and INPUT LO terminals.

d. Set the 8110A to the 10 volt range.

e. Apply −10.0000 volts dc to the INPUT terminals.

f. Adjust the 10V CAL control (R6) for the same value measured in step (c) (±10 uV).

## 4-65. A/D Converter Offset.

a. Disconnect the differential voltmeter from TP1.

b. Set the 8110A to the 1 volt dc range with the FILTER switch ON.

c. Apply +0.00055 volts dc to the input terminals.

d. Adjust the A-D OFFSET control (R206) for a readout alternating between .0005 and .0006. Check for proper adjustment by ensuring that the readout is (1) steady at +.0006 with a +0.00059 volt input and (2) steady at +.0005 with a +0.00053 volt input.

e. Reverse input polarity and ensure that readout is (1) steady at −.0006 with a −0.00059 volt input and (2) steady at −.0005 with a −0.00054 volt input.

f. Apply −0.00010 volts dc and ensure that readout is either steady at −.0001 or alternates between .0000 and −.0001.

g. Apply −0.00002 volts dc and ensure that readout is ±.0000.

### 4-66. −VDC Cal.

a. Set the 8110A to the 1 volt dc range with the FILTER switch ON.

b. Apply −1.00055 volts dc to the INPUT terminals.

c. Adjust −DCV CAL control (R23) for a readout alternating between −1.0005 and −1.0006. Check for proper adjustment by ensuring that the readout is (1) steady at −1.0006 with a −1.00058 volt input and (2) steady at −1.0005 with a −1.00052 volt input.

### 4-67. +VDC Cal.

a. Set the 8110A to the 1 volt dc range with the FILTER switch ON.

b. Apply +1.00055 volts dc to the INPUT terminals.

c. Adjust +DCV CAL control (R50) for a readout alternating between +1.0005 and +1.0006. Check for proper adjustment by ensuring that the readout is (1) steady at +1.0006 with a +1.00058 volt input and (2) steady at +1.0005 with a +1.00052 volt input.

### 4-68. Trip Point Adjustment

a. Set the 8110A to the 1 volt dc range with the FILTER switch ON.

b. Apply −0.09995 volts dc to the INPUT terminals.

c. Adjust the DCV TRIP POINT ADJ control (R208) for a readout alternating between −.099X and −.1000. Check for proper adjustment by ensuring that readout is (1) steady at −.099X with a −0.09993 volt input and (2) steady at −.1000 with a −0.09997 volt input.

*NOTE!*

*The "X" digit may be any of several numbers, depending on adjustment of the REMAINDER ADJ control, which will be adjusted in the next section of the calibration procedure. The actual value does not affect trip point adjustment.*

d. Reverse input polarity and ensure that readout is (1) steady at +.1000 with a +0.09999 volt input and (2) steady at +.099X with a +0.09992 volt input.

### 4-69. Remainder Adjustment

a. Set the 8110A to the 1 volt dc range.

b. Apply −0.09965 volts dc to the INPUT terminals.

c. Adjust the REMAINDER ADJ control (R149) for a readout alternating between −.0996 and −.0997. Check for proper adjustment by ensuring that readout is (1) steady at −.0997 with a −0.09966 volt input, (2) steady at −.0996 with a −0.09962 volt input, and (3) steady at +.0999 and −.0999 with +0.0999 and −0.0999 volt inputs respectively.

### 4-70. Kilohms Cal

a. Set the 8110A function to KΩ, RANGE to 1000, and FILTER to ON.

b. Connect a 100.00 kΩ resistor to the INPUT terminals.

c. Adjust K OHM CAL control (R48) for a 100.00 readout.

d. Set the 8110A to the 1 kΩ range.

e. Connect a 1.0000 kΩ resistor to the INPUT terminals. Readout should be 1.0000 ±0.0001 kΩ.

f. Set the 8110A to the 10 kΩ range.

g. Connect a 10.000 kΩ resistor to the INPUT terminals. Readout should be 10.000 ±0.001 kΩ.

h. Set the 8110A to the 1000 kΩ range.

i. Connect a 1000.0 kΩ resistor to the INPUT terminals. Readout should be 1000.0 ±0.1 kΩ.

j. Set the 8110A to the 1 kΩ range.

k. Short the INPUT terminals with a shorting bar. Readout should be ⩽ .0001.

## 4-71. 10 Megohm Cal

a. Set the 8110A function to 10 MΩ and FILTER to ON.

b. Connect a 10 MΩ resistor to the INPUT terminals.

c. Adjust the 10 MEG CAL control (R153) for a readout of 10.000 ±2 digits. Allow adequate time for instrument to settle before finalizing adjustment.

## 4-72. VAC Cal

a. Set 8110A function to VDC and RANGE to 1000. Ensure that readout is +000.0. If not, perform the zero adjustment procedure, paragraph 4 - 63.

b. Set 8110A function to VAC and RANGE to 1000. Readout should be between 000.0 and 000.3.

c. Set 8110A RANGE as shown in Table 4-7 and perform the indicated operations.

Table 4-7. AC CALIBRATION

| STEP | 8110A RANGE | INPUT SIGNAL | OPERATION |
|---|---|---|---|
| d. | 1 | 1V, 1 kHz | Adjust ACV CAL (R134) for a readout of 1.0000. |
| e. | 1 | 1V, 20 kHz | Adjust 1V HF ADJ (C14) for a readout of 1.0000. |
| f. | 1 | 1V, 10 kHz | Readout should be between .9993 and 1.0008. If not, re-adjust C14 to bring reading within tolerance. |
| g. | 1 | 1V, 10 kHz | Readout should be between .9975 and 1.0020. |
| h. | 1 | 100 MV, 2 kHz | Readout should be between .0998 and .1002. |
| i. | 1 | 100 MV, 10 kHz | Readout should be between .0996 and .1004. |
| j. | 1 | 100 MV, 20 kHz | Readout should be between .0992 and .1008. |
| k. | 10 | 10V, 2 kHz | Readout should be between 9.995 and 10.005 |
| l. | 10 | 10V, 20 kHz | Adjust 10V HF ADJ (C15) for a readout of 10.000. |
| m. | 100 | 100V, 1 kHz | Readout should be between 99.93 and 100.07. |
| n. | 100 | 100V, 20 kHz | Readout should be between 99.70 and 100.30. |
| o. | 100 | 100V, 10 kHz | Readout should be between 99.70 and 100.30. |
| p. | 1000 | 1000V, 2 kHz | Allow time for settling. Readout should be between 998.3 and 1001.7. |
| q. | 1000 | 1000V, 10 kHz | Readout should be between 998.3 and 1001.7. |
| r. | 1000 | 1000V, 20 kHz | Readout should be between 996.0 and 1004.0. |
| s. | | | Calibration of the 8110A is complete |

SECTION 5

# List of Replaceable Parts

## 5-1. INTRODUCTION

5-2. This section of the manual is a complete illustrated parts list breakdown itemizing all assemblies and their components for this instrument. Illustrations for each listing aid in locating the assemblies and components. A Cross Reference List of Fluke stock numbers to original manufactures' part number is included at the rear of this section.

5-3. Assemblies and subassemblies are identified by a reference designation beginning with the letter A followed by a number (e.g., A1 etc). Electrical components appearing on the schematic diagram are identified by their schematic diagram reference designation. Components not appearing on the schematic diagram are identified by Fluke stock numbers on the illustrations. Flagnotes are sometimes used and refer to special ordering explanations.

## 5-4. PARTS LIST COLUMN DESCRIPTIONS

a. The REF DESIG column indexes the item description to the associated illustration. In general the reference designations are listed under each assembly in alpha-numeric order. Subassemblies of minor proportions are sometimes listed with the assembly of which they are a part. In this case, the reference designations for the components of the subassembly may appear out of order.

b. The DESCRIPTION column describes the salient characteristics of the component. Indention of the description indicates the relationship to other assemblies, components, etc. In many cases it is necessary to abbreviate in this column. For abbreviations and symbols used, refer to Appendix B located at the rear of the manual.

d. The TOT QTY column lists the total quantity of the items used in the instrument and reflects the latest Use Code. Second and subsequent listings of the same item are referenced to the first listing with the abbreviation REF. The TOT QTY column lists the total quantity of the item in that particular assembly.

e. Entries in the REC QTY column indicate the recommended number of spare parts necessary to support one to five instruments for a period of two years. This list presumes an availability of common electronic parts at the maintenance site. For maintenance for one year or more at an isolated site, it is recommended that at least one of every part in the instrument be stocked. In the case of optional subassemblies, plug-ins, etc. that are not always part of the instrument, or are deviations from the basic instrument model, the REC QTY column list the recommended quantity of the item in that particular assembly.

f. The USE CODE column identifies certain parts which have been added, deleted or modified during the production of the instrument. Each part for which a Use Code has been assigned may be identified with a particular instrument serial number by consulting the Serial Number Effectivity List, paragraph 5-9. Sometimes when a part is changed, the new part can and should be used as a replacement for the original part. In this event a parenthetical note is added in the DESCRIPTION column.

## 5-5. MANUFACTURES' CROSS REFERENCE LIST COLUMN DESCRIPTIONS

a. The six-digit part number by which the item is identified at the John Fluke Mfg. Co., is listed in the FLUKE STOCK NO. column. Use this number when ordering parts from the factory or authorized representatives.

b. The Federal Supply Code for the item manufacturer is listed in the MFG column. An abbreviated list of Federal Supply Codes is included in the Appendix.

c. The part number which uniquely identifies the item to the original manufacturer is listed in the MFG PART NO. column. If a component must be ordered by description, the type number is listed.

## 5-6. HOW TO OBTAIN PARTS

5-7. Standard components have been used wherever possible. Standard components may be ordered directly from the manufacturer by using the manufacturer's part number, or parts may be ordered from the John Fluke Mfg. Co. factory or authorized representatives by using the Fluke part number. In event the part you order has been replaced by a new or improved part, the replacement will be accompanied by an explanatory note and installation instructions, if necessary.

5-8. You can insure prompt and efficient handling of your order to the John Fluke Mfg. Co., if you include the following information:

a. Quantity.

b. FLUKE Stock Number.

c. Description

d. Reference Desingation.

e. Instrument model and serial number.

Example: 2 each, 168708, Transistor, 2N3391, A1Q86 & Q87 for 8110A, S/N123.

If your must order structural parts not listed in the parts list, describe the part as completely as possible. A sketch of the part, showing its location to other parts of the instrument, is usually most helpful.

## 5-9. SERIAL NUMBER EFFECTIVITY

5-10. A Use Code column is provided to identify certain parts that have been added, deleted or modified during production of the Model 8110A. Each part for which a use code has been assigned may be identified with a particular instrument serial number by consulting the Use Code Effectivity List below. All parts with no code are used on all instruments with serial numbers above 123.

| USE CODE | EFFECTIVITY |
|---|---|
| NONE | Model 8110A serial number 123 and on. |
| A | Model 8110A serial number 123 thru 316. |
| B | Model 8110A serial number 317 and on. |

| REF DESIG | DESCRIPTION | STOCK NO | TOT QTY | REC QTY | USE CODE |
|---|---|---|---|---|---|
| | **DIGITAL MULTIMETER — Figure 5-1** | 8110A | | | |
| A1 | Main PCB Assembly (See Figure 5-2) | 286583 | 1 | | |
| | Input Divider Assembly (See Figure 5-2) | 285593 | 1 | | |
| F1 | Fuse, slow blow, 1/8 amp, 250v (for 115v operation) | 166488 | 1 | | |
| F1 | Fuse, slow blow, 1/16 amp, 250v (for 230v operation) | 163030 | | | |
| J1 | Binding post, red, HI | 275552 | 1 | | |
| J2 | Binding post, black, LO | 275560 | 1 | | |
| J3 | Binding post, blue, GUARD | 275578 | 1 | | |
| P1 | Connector, male, 3 contact | 222612 | 1 | | |
| S11 | Switch, slide, dpdt | 226274 | 1 | | |
| T101 | Transformer, power | 275354 | 1 | | |
| W1 | Line cord | 226100 | 1 | | |
| XF1 | Fuse holder | 103283 | 1 | | |
| | Cable, AC Power | 269779 | 1 | | |
| | Cable, Input | 269761 | 1 | | |
| | Cover, bottom | 269639 | 1 | | |
| | Cover, top | 269647 | 1 | | |
| | Foot, plstc | 259654 | 2 | | |
| | Foot, plstc | 259380 | 2 | | |
| | Push button, gray | 268896 | 9 | 2 | |
| | Push button, green | 268862 | 1 | 2 | |
| | Shaft, switch extension | 269688 | 9 | | |
| | Shorting link | 101220 | 1 | | |

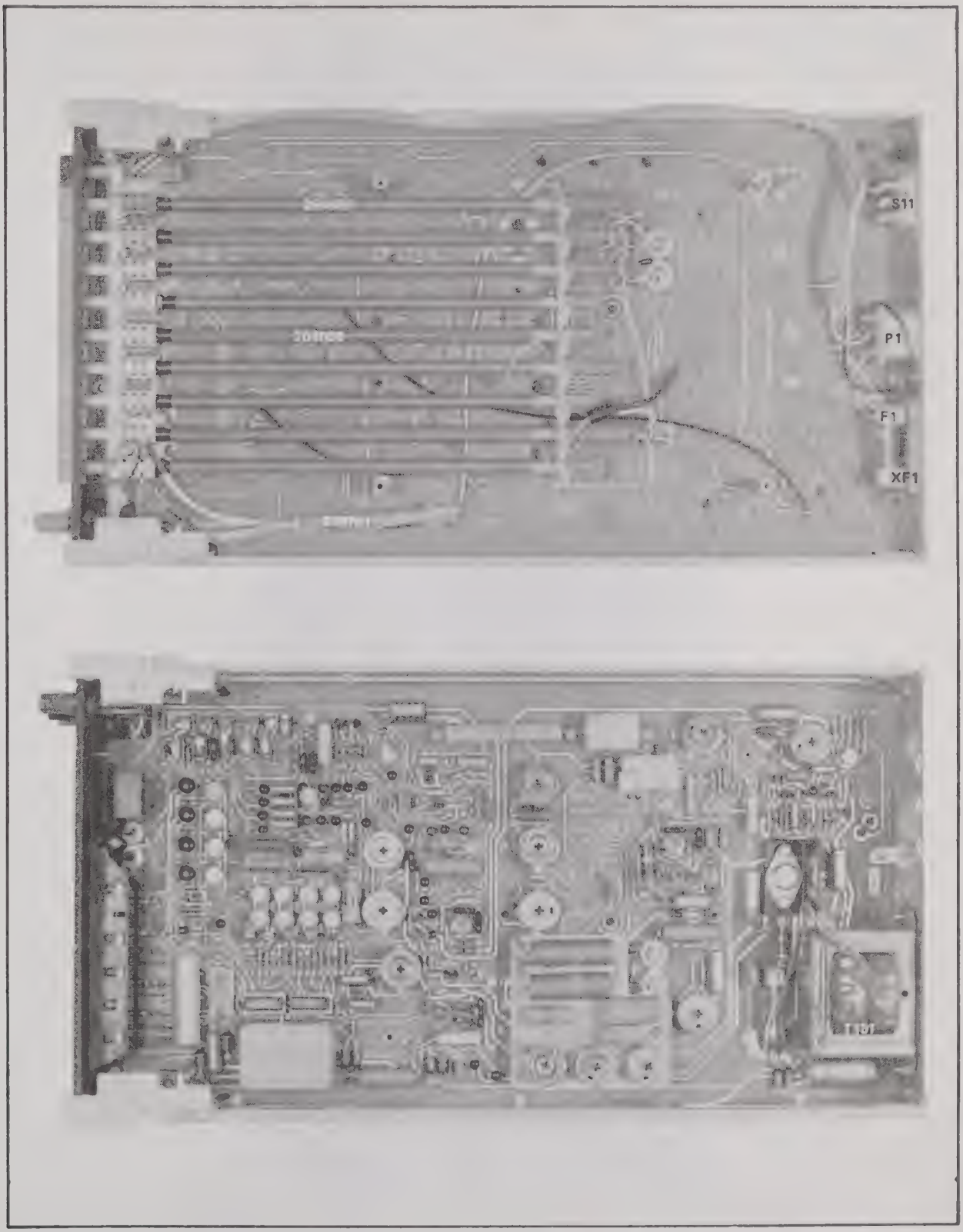



Figure 5-1. 8110A MULTIMETER (Sheet 1 of 2)

Figure 5-1. 8110A MULTIMETER (Sheet 2 of 2)

| REF DESIG | DESCRIPTION | STOCK NO | TOT QTY | REC QTY | USE CODE |
|---|---|---|---|---|---|
| A1 | MAIN PCB ASSEMBLY - Figure 5-2 | 286583 | REF | | |
| | Input Divider Assembly (See Figure 5-2) | 285593 | REF | | |
| A1, A2 | IC, operational amplifier | 271502 | 2 | 1 | |
| A3 | IC, DTL, triple 3-Input NAND Gate | 266312 | 1 | 1 | |
| A4 | IC, DTL, Binary Counter | 267153 | 1 | 1 | |
| A5 | IC, Decoder Driver, DM/SN7441AN, NS8840N | 267211 | 1 | 1 | |
| C1 | Cap, elect, 250 uf +50/−10%, 40v | 178616 | 1 | 1 | |
| C2 | Cap, cer, 3300 pf ±20%, 1 kv | 106674 | 1 | | |
| C3, C7 | Cap, elect, 50 uf +75/−10%, 25v | 148650 | 2 | 1 | |
| C4 | Cap, plstc, 0.47 uf, factory selected | 279422 | 1 | 1 | |
| C5, C8, C18 | Cap, elect, 50 uf +50/−10%, 25v | 168823 | 3 | 1 | |
| C6 | Cap, elect, 2 uf +50/−10%, 150v | 267310 | 1 | 1 | |
| C9 | Cap, plstc, 0.22 uf ±10%, 1 kv | 275495 | 1 | 1 | |
| C10 | Cap, plstc, 0.1 uf ±20%, 120v | 167460 | 1 | | |
| C11, C43 | Cap, plstc, 0.033 uf ±10%, 250v | 234492 | 2 | | |
| C12 | Cap, Plstc, 0.068 uf ±20%, 120v | 260570 | 1 | | |
| C13 | Cap, plstc, 0.027 uf ±10%, 250v | 267120 | 1 | | |
| C14 | Cap, var, 0.5 −5pf, 500v | 267914 | 1 | | |
| C15 | Cap, var, 1-8 pf, 500v | 267906 | 1 | | |
| C19, C37, C44 | Cap, plstc, 1.0 uf ±10%, 250v | 190330 | 3 | | |
| C20, C54 | Cap, plstc, 0.22 uf ±10%, 250v | 194803 | 2 | | |
| C21 | Cap, elect, 5 uf +50/−10%, 64v | 218966 | 1 | 1 | |
| C22 thru C26 | Cap, plstc, 0.1 uf, factory selected | 279430 | 5 | 2 | |
| C27 | Cap, mica, 330 pf ±5%, 500v | 148445 | 1 | | |
| C28 | Cap, mica, 100 pf ±5%, 500v | 148494 | 1 | | |
| C29 | Cap, plstc, 0.47 uf ±10%, 250v | 184366 | 1 | | |
| C30 thru C33, C59, C64 | Cap, plstc, 0.022 uf ±10%, 250v | 234484 | 6 | | |
| C34 | Cap, plstc, 0.047 uf ±10%, 120v | 260562 | 1 | | |

| REF DESIG | DESCRIPTION | STOCK NO | TOT QTY | REC QTY | USE CODE |
|---|---|---|---|---|---|
| C35, C50, C58, C62, C66 | Cap, plstc, 0.1 uf ±10%, 250v | 161992 | 5 | | |
| C36, C52, C57 | Cap, mica, 33 pf ±5%, 500v | 160317 | 3 | | |
| C38 | Cap, cer, 0.0012 uf ±10%, 500v | 106732 | 1 | | |
| C39 | Cap, mica, 470 pf ±10%, 500v | 148429 | 1 | | |
| C42 | Cap, plstc, 0.047 uf ±10%, 250v | 162008 | 1 | | |
| C45, C46 | Cap, mica, 47 pf ±5%, 500v | 148536 | 1 | | |
| C48 | Cap, elect, 1 uf +75/−10%, 25v | 165886 | 1 | | |
| C51 | Cap, mica, 150 pf ±5%, 500v | 148478 | 1 | | |
| C55 | Cap, mica, 4 pf ±5%, 500v | 190397 | 1 | | |
| C60 | Cap, cer, 0.001 uf ±20%, 3 kv | 105635 | 1 | | |
| C61 | Cap, cer, 150 pf ±20%, 3 kv | 277004 | 1 | | |
| C65 | Cap, elect, 4 uf +50/−10%, 350v | 241398 | 1 | 1 | A |
| C65 | Cap, elect, 3 uf +50/−10%, 250v | 306555 | 1 | 1 | B |
| CR1, CR2, CR5 thru CR8, CR10 | Diode, silicon, 1 amp, 100 piv | 116111 | 7 | | |
| CR3, CR45 | Diode, silicon, 1 amp, 600 piv | 112383 | 2 | 2 | |
| CR4, CR16, CR18, CR19, CR20, CR23, CR26, CR27, CR36, CR38 thru CR44, CR46, CR47, CR48 | Diode, silicon, high speed switching | 289595 | 19 | 3 | |
| CR11, CR12 | Diode, silicon, 10 ma, 2 piv | 180554 | 2 | 1 | |
| CR13, CR49 | Diode, silicon, 150 ma | 234468 | 2 | 1 | |
| CR14, CR15 | Diode, silicon, 75 ma, 25 piv | 241422 | 2 | 1 | |
| CR17, CR35 | Diode, silicon, 200 ma, 25 piv | 190272 | 2 | 1 | |
| CR37 | Diode, zener, 3.9v | 113316 | 1 | 1 | |
| DS2 | Lamp, neon | 266478 | 1 | 1 | |
| F2 | Fuse, fast acting, ¼ amp, 250v | 109314 | 1 | 10 | |
| Q1 | Tstr, silicon, NPN | 183004 | 1 | 1 | |

| REF DESIG | DESCRIPTION | STOCK NO | TOT QTY | REC QTY | USE CODE |
|---|---|---|---|---|---|
| Q2, Q3, Q6, Q9, Q14, Q15, Q24, Q26, Q79 | Tstr, Silicon, PNP | 195974 | 9 | 2 | |
| Q4, Q5 | Tstr, silicon, NPN | 272237 | 2 | 1 | |
| Q7, Q8, Q42, Q45, Q48, Q51, Q59, Q60, Q75, Q80, Q84 | Tstr, silicon, NPN | 218396 | 11 | 2 | |
| Q10 | Tstr, silicon, NPN | 168716 | 1 | 1 | |
| Q11 | Tstr, factory selected & matched to R15 & R22 | 1 | | 1 | |
| Q12 | Tstr, factory selected & matched to Q52 | 2 | | 2 | |
| Q13, Q16, Q17, Q18, Q27 thru Q39, Q58, Q65 | Tstr, FET, N-channel | 288324 | 19 | 5 | |
| Q19 thru Q23, Q25, Q76, Q88, Q89 | Tstr, silicon, PNP | 288761 | 9 | 2 | |
| Q40, Q43, Q46, Q49 | Tstr, germanium, NPN | 182691 | 4 | 1 | |
| Q41, Q44, Q47, Q50 | Tstr, germanium, PNP | 182709 | 4 | 1 | |
| Q52 | Tstr, factory selected & matched to Q12 | 2 | | | |
| Q53 | Tstr, FET, dual, N-channel | 257501 | 1 | 1 | |
| Q66, Q81, Q82 | Tstr, silicon, NPN | 245480 | 3 | 1 | |
| Q67 thru Q70 | Tstr, silicon, NPN | 218511 | 4 | 1 | |
| Q71 thru Q74 | Tstr, silicon, PNP | 266619 | 4 | 1 | |
| Q77 | Tstr, FET, N-channel, selected | 287623 | 1 | 1 | |
| Q85 | Tstr, FET, N-channel | 261578 | 1 | 1 | |

| REF DESIG | DESCRIPTION | STOCK NO | TOT QTY | REC QTY | USE CODE |
|---|---|---|---|---|---|
| Q86, Q87 | Tstr, silicon, NPN | 168708 | 2 | 1 | |
| R1 | Res, comp, 470Ω ±10%, 1w | 109710 | 1 | | |
| R2, R9, R11, R54, R199 | Res, comp, 1k ±5%, ¼w | 148023 | 5 | | |
| R3, R120, R207 | Res, comp, 33k ±5%, ¼w | 148155 | 3 | | |
| R4 | Res, met flm, 38.3k ±1%, 1/8w | 241372 | 1 | | |
| R5, R102, R103, R154 | Res, met flm, 34k ±1%, 1/8w | 261602 | 4 | | |
| R6, R7, R40, R47, R161 | Res, met flm, 14.7k ±1%, 1/8w | 226225 | 5 | | |
| R8, R35, R37, R52, R191 | Res, comp, 220k ±5%, ¼w | 160937 | 5 | | |
| R10, R169 | Res, comp, 270Ω ±5%, ¼w | 160804 | 2 | | |
| R12 | Res, comp, 100k ±5%, ¼w | 148189 | 1 | | |
| R13 | Res, met flm, 12.1k ±1%, 1/8w | 234997 | 1 | | |
| R14 | Res, met flm, 2.94k ±1%, 1/8w | 261628 | 1 | | |
| R15 | Res, met flm, factory selected and matched to Q11 & R22 | 1 | | | |
| R16, R56, thru R60, R73, R180 | Res, comp, 47k ±5%, ¼w | 148163 | 8 | | |
| R17, R19, R53, R172, R178, R181 | Res, comp, 3.3k ±5%, ¼w | 148056 | 6 | | |
| R18 | Res, met flm, 10k ±1%, 1/8w | 168260 | 1 | | |
| R20 | Res, met flm, 412Ω ±1%, 1/8w | 261636 | 1 | | |
| R21, R101, R111 | Res, met flm, 19.1k ±1%, 1/8w | 234963 | 3 | | |
| R22 | Res, met flm, factory selected & matched to Q11 & R15 | 1 | | | |
| R23, R34, R153 | Res, var, ww, 10k ±10%, 2w | 272740 | 3 | 1 | |
| R24 | Res, met flm, 1M ±0.1%, 2w | 225953 | 1 | | |
| R27 | Res, comp, 1M ±10%, 2w | 268227 | 1 | | |
| R28 | Res, comp, 1.2M ±5%, ¼w | 188425 | 1 | | |

| REF DESIG | DESCRIPTION | STOCK NO | TOT QTY | REC QTY | USE CODE |
|---|---|---|---|---|---|
| R29 | Res, met flm, 449.1k, matched | 3 | | | |
| R30 | Res, met flm, 49.9k, matched | 3 | | | |
| R31 | Res, met flm, 4.99k, matched | 3 | | | |
| R32 | Res, met flm, 499Ω, matched | 3 | | | |
| R36 | Res, comp, 820k ±5%, ¼w | 220541 | 1 | | |
| R39 | Res, comp, 18k ±5%, ¼w | 148122 | 1 | | |
| R42 | Res, met flm, 499k ±1%, 1/8w | 268813 | 1 | | |
| R43 | Res, met flm, 453k ±1%, 1/8w | 295709 | 1 | | |
| R45, R46, R62 thru R66, R71 | Res, comp, 22k ±5%, ¼w | 148130 | 8 | | |
| R48, R149 | Res, var, ww, 200Ω ±20%, 1¼w | 144766 | 2 | 1 | |
| R49 | Res, ww,6.45k ±0.5%, ½w | 184416 | 1 | 1 | |
| R50 | Res, var, ww, 10Ω ±10%, 1¼w | 112672 | 1 | | |
| R51 | Res, ww, 2.853k ±0.03%, ½w | 291039 | 1 | 1 | |
| R61, R152 | Res, met flm, 200k ±1%, 1/8w | 261701 | 2 | | |
| R67 | Res, comp, 270k ±5%, ¼w | 220061 | 1 | | |
| R68, R70 | Res, comp, 150k ±5%, ¼w | 182212 | 2 | | |
| R69, R205 | Res, comp, 470k ±5%, ¼w | 188441 | 2 | | |
| R72 | Res, comp, 1.5M ±5%, ¼w | 182857 | 1 | | |
| R74, R80, R85, R90 R95, R110, R118, R119, R128, R141 thru R144 | Res, comp, 10k ±5%, ¼w | 148106 | 13 | | |
| R75 | Res, met flm, 8.66k ±1%, 1/8w | 260364 | 1 | | |
| R77 | Res, ww, 3.4483k, matched | 4 | | 1 | |
| R78 | Res, met flm, 422k ±1%, 1/8w | 276626 | 1 | | |
| R79 | Res, ww, 200k, matched | 4 | | 1 | |
| R81, R86, R91, R96, R170 | Res, comp, 15k ±5%, ¼w | 148114 | 5 | | |
| R83 | Res, met flm, 232k ±1%, 1/8w | 276618 | 1 | | |
| R84 | Res, ww, 100k, matched | 4 | | 1 | |

| REF DESIG | DESCRIPTION | STOCK NO | TOT QTY | REC QTY | USE CODE |
|---|---|---|---|---|---|
| R88, R93 | Res, met flm, 121k ±1%, 1/8w | 229369 | 2 | | |
| R89 | Res, ww, 50k, matched | 4 | | 1 | |
| R94 | Res, ww, 50k, matched | 4 | | 1 | |
| R98 | Res, ww, 200k, matched | 4 | | 1 | |
| R99 | Res, met flm, 11.9k ±0.25%, 1/8w | 290007 | 1 | | |
| R100 | Res, met flm, 2k ±0.25%, 1/8w | 289991 | 1 | | |
| R104 | Res, met flm, 45.3k ±1%, 1/8w | 234971 | 1 | | |
| R112, R200 | Res, comp, 2.2M ±5%, ¼w | 198390 | 2 | | |
| R121, R188, R189, R198, R201, R202, R211 | Res, comp, 2.2k ±5%, ¼w | 148049 | 7 | | |
| R124 | Res, comp, 4.7k ±5%, ¼w | 148072 | 1 | | |
| R127, R166 | Res, comp, 12k ±5%, ¼w | 159731 | 2 | | |
| R130 | Res, comp, 62k ±5%, ¼w | 220053 | 1 | | |
| R131 thru R138 | Res, comp, 180k ±5%, ¼w | 193441 | 8 | | |
| R145 | Res, comp, 1.1k ±5%, ¼w | 267336 | 1 | | |
| R146, R147 R194 | Res, comp, 1.6k ±5%, ¼w | 266197 | 3 | | |
| R155 | Res, comp, 15Ω ±5%, ¼w | 147876 | 1 | | |
| R162 | Res, met flm, 1.18k ±1%, 1/8w | 268409 | 1 | | |
| R163, R164 | Res, met flm, 35k ±0.1%, 1/8w | 229443 | 2 | | |
| R165 | Res, met flm, 46.4k ±1%, 1/8w | 188375 | 1 | | |
| R174 | Res, met flm, 453Ω ±1%, 1/8w | 267393 | 1 | | |
| R175 | Res, var, ww, 200Ω ±10%, 2w | 184465 | 2 | | |
| R176 | Res, met flm, 13.7Ω ±1%, 1/8w | 272815 | 1 | | |
| R177 | Res, met flm, 28.7Ω ±1%, 1/8w | 272823 | 1 | | |
| R186 | Res, comp, factory selected | 5 | | | |
| R187 | Res, comp, 3.3Ω ±5%, ¼w | 182279 | 1 | | |
| R193 | Res, comp, 6.2Ω ±5%, ¼w | 272831 | 1 | | |
| R195, R196 | Res, comp, 470Ω ±5%, ¼w | 147983 | 2 | | |
| R197 | Res, comp, 27Ω ±5%, ¼w | 160812 | 1 | | |

| REF DESIG | DESCRIPTION | STOCK NO | TOT QTY | REC QTY | USE CODE |
|---|---|---|---|---|---|
| R203 | Res, met flm, 2M ±1%, ½w | 217760 | 1 | | |
| R204 | Res, met flm, 715k ±1%, 1/8w | 236836 | 1 | | |
| R206 | Res, var, ww, 5Ω ±20%, 1¼w | 166348 | 1 | 1 | |
| R208 | Res, var, ww, 500Ω ±10%, 1¼w | 112433 | 1 | 1 | |
| R209 | Res, comp 82k ±5%, ¼w | 188458 | 1 | | |
| R210 | Res, comp. 1M ±5%, ¼w | 182204 | 1 | | |
| S1 thru | Switch assembly, front, S1-S10 | 279406 | 1 | | |
| S10 | Switch assembly, rear, S1-S10 | 279448 | 1 | | |
| T102 | Transformer, inverter | 253583 | 1 | 1 | |
| V1 thru V4 | Tube, neon readout | 266502 | 4 | 2 | A |
| V1 thru V4 | Tube, neon readout | 271494 | 4 | 2 | B |
| V5 | Tube, polarity indicator | 272992 | 1 | 1 | |
| XA3, XA4 | Socket IC, 14 contact | 276527 | 2 | 1 | |
| XA5 | Socket, IC, 16 contact | 276535 | 1 | 1 | |
| XDS2 | Socket, lamp | 279372 | 1 | | |
| XF1 | Fuse holder clip | 284984 | 2 | | |
| XV1 thru XV5 | Socket, tube | 268714 | 5 | | |
| | Heat sink, Q1 | 186759 | 1 | | |

1 Q11, R15 and R22 are a matched set and must be replaced as a set. For replacement, order Reference -Amplifier Set, part number 269803.

2 Q12 and Q52 are a J-FET matched set and must be replaced as a set. For replacement, order part number 265744.

3 R29 thru R32 are a matched set and must be replaced as a set. For replacement, order AC Converter Resistor Set, part number 257014.

4 R77, R79, R84, R89, R94 and R98 are a matched Ladder Divider Resistor Set, part number 269795. However, the resistors may be replaced individually if model, serial number, full reference designation and all information stamped on the old resistor are included when ordering a new one.

5 R186 is factory selected. For replacement, replace with exact value.

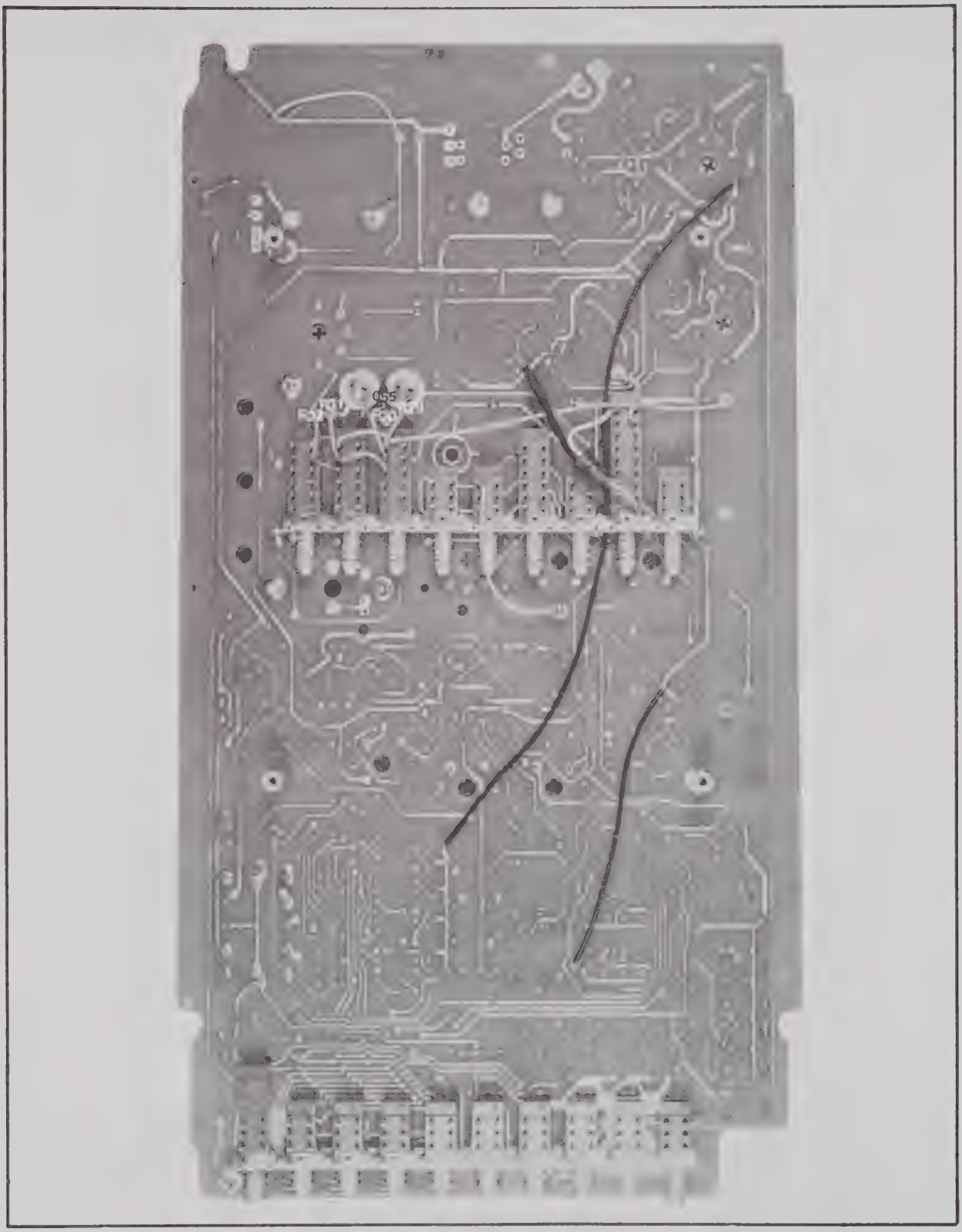


Figure 5-2. MAIN PCB ASSEMBLY (Sheet 1 of 2)

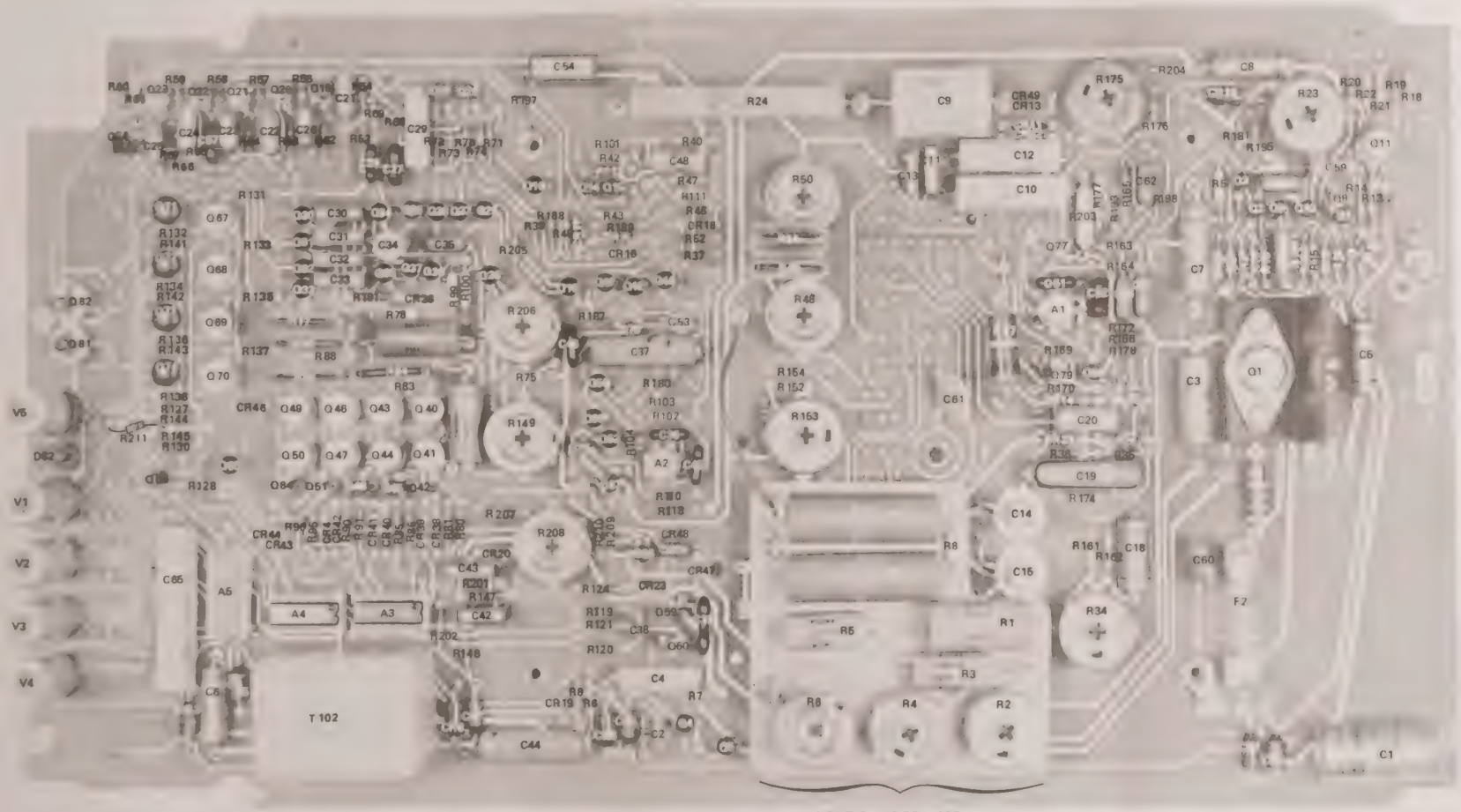



Figure 5-2. MAIN PCB ASSEMBLY (Sheet 2 of 2)

| REF DESIG | DESCRIPTION | STOCK NO | TOT QTY | REC QTY | USE CODE |
|---|---|---|---|---|---|
| | **INPUT DIVIDER ASSEMBLY (See Figure 5-2)** | 285593 | REF | | |
| R1 | Res, ww, 10k ±0.03%, 1w | 274514 | 1 | 1 | |
| R2 | Res, var, ww, 20Ω ±10%, 2w | 184457 | 1 | 1 | |
| R3 | Res, ww, 90k ±0.03%, ¾w | 253476 | 1 | 1 | |
| R4 | Res, var, ww, 200Ω ±10%, 2w | 184465 | REF | 1 | |
| R5 | Res, ww, 900k ±0.03%, ¾w | 253468 | 1 | 1 | |
| R6 | Res, var, ww, 2k ±5%, 1¼w | 160705 | 1 | 1 | |
| R7, R8, R9 | Resistor set, selected & matched (Replace as a set) | 286708 | 1 | 1 | |

## MANUFACTURERS' CROSS REFERENCE LIST

| FLUKE STOCK NO. | MFR. | MFR. PART NO. |
|---|---|---|
| 101220 | 24655 | 0938-9712 |
| 103283 | 71400 | 4405 |
| 105635 | 56289 | 29C300 |
| 106674 | 56289 | C023B102G332M |
| 106732 | 71590 | CF-122 |
| 109314 | 71400 | Type AGC |
| 109710 | 01121 | GB4711 |
| 112383 | 05277 | 1N4822 |
| 112433 | 71540 | Type 110 |
| 112672 | 71450 | Type 110 |
| 113316 | 07910 | 1N748 |
| 116111 | 05277 | 1N4817 |
| 144766 | 71450 | Type 110 |
| 147876 | 01121 | CB1505 |
| 147983 | 01121 | CB4715 |
| 148023 | 01121 | CB1025 |
| 148049 | 01121 | CB2225 |
| 148056 | 01121 | CB3325 |
| 148072 | 01121 | CB4725 |
| 148106 | 01121 | CB1035 |
| 148114 | 01121 | CB1535 |
| 148122 | 01121 | CB1835 |
| 148130 | 01121 | CB2235 |
| 148155 | 01121 | CB3335 |
| 148163 | 01121 | CB4735 |
| 148189 | 01121 | CB1045 |
| 148429 | 14655 | CD19F471J |
| 148445 | 14655 | CD15F331J |
| 148478 | 14655 | CD15F151J |
| 148494 | 14655 | CD15F101J |
| 148536 | 14655 | CD15E470J |
| 148650 | 06001 | 76F02KL500 |
| 159731 | 01121 | CB1235 |
| 160317 | 14655 | CD15E330J |
| 160705 | 71450 | Type 110 |
| 160804 | 01121 | CB2715 |
| 160812 | 01121 | CB2705 |
| 160937 | 01121 | CB2245 |
| 161992 | 73445 | C280AE/A100K |
| 162008 | 73445 | C280AE/A47K |
| 163030 | 71400 | MDL 1/16 |
| 165886 | 56289 | 30D105G025BA4 |
| 166348 | 71450 | Type 110 |
| 166488 | 71400 | MDL 1/8 |
| 167460 | 84411 | Type 863uw |
| 168260 | 91637 | Type MFF 1/8 |
| 168708 | 03508 | 2N3391 |
| 168716 | 07263 | S19254 |
| 168823 | 73445 | C426ARF50 |
| 178616 | 73445 | C437ARG250 |
| 180554 | 07910 | CD12599 |
| 182204 | 01121 | CB1055 |
| 182212 | 01121 | CB1545 |
| 182279 | 01121 | CB33G5 |
| 182691 | 01295 | GA3937 |
| 182709 | 01295 | GA3938 |
| 182857 | 01121 | CB1555 |
| 183004 | 95303 | 40250 |
| 184366 | 73445 | C280AE/A470K |
| 184416 | 89536 | 184416 |
| 184457 | 71450 | Type 115 |
| 184465 | 71450 | Type 115 |
| 186759 | 89536 | 186759 |
| 188375 | 91637 | Type MFF 1/8 |
| 188425 | 01121 | CB1255 |
| 188441 | 01121 | CB4745 |
| 188458 | 01121 | CB8235 |
| 190272 | 93332 | 1N456A |
| 190330 | 73445 | C280AE/A1M |
| 190397 | 14655 | CD15C040K |
| 193441 | 01121 | CB1845 |
| 194803 | 73445 | C280AE/A220K |
| 195974 | 04713 | 2N3906 |

## MANUFACTURERS' CROSS REFERENCE LIST

| FLUKE STOCK NO. | MFR. | MFR. PART NO. |
|---|---|---|
| 198390 | 01121 | CB2255 |
| 217760 | 91637 | Type MFF ½ |
| 218354 | 08806 | 1252 |
| 218396 | 04713 | 2N3904 |
| 218511 | 95303 | 60994 |
| 218735 | 01121 | EB20G5 |
| 218966 | 73445 | C426ARH5 |
| 220053 | 01121 | CB6235 |
| 220061 | 01121 | CB2735 |
| 220541 | 01121 | CB8245 |
| 222612 | 82389 | AC3G |
| 225953 | 03888 | Type PME80 |
| 226100 | 70903 | 17258 |
| 226225 | 91637 | Type MFF 1/8 |
| 226274 | 82389 | 46256-LF |
| 229369 | 91637 | Type MFF 1/8 |
| 229443 | 91637 | Type MFF 1/8 |
| 234468 | 07910 | CD9039 |
| 234484 | 73445 | C280AE/A22K |
| 234492 | 73445 | C280AE/A33K |
| 234963 | 91637 | Type MFF 1/8 |
| 234971 | 91637 | Type MFF 1/8 |
| 236836 | 91637 | Type MFF 1/8 |
| 241372 | 91637 | Type MFF 1/8 |
| 241398 | 56289 | 34D405F400EJ2 |
| 241422 | 03508 | 1N4009 |
| 245480 | 07263 | S24496 |
| 253468 | 89536 | 253468 |
| 253476 | 89536 | 253476 |
| 253583 | 89536 | 253583 |
| 257014 | 89536 | 257014 |
| 257501 | 17856 | DN423 |
| 259654 | 89536 | 259654 |
| 260364 | 91637 | Type MFF 1/8 |
| 260562 | 84411 | 863UW47391 |
| 260570 | 84411 | 863UW68391 |
| 261578 | 15818 | U2366E |
| 261602 | 91637 | Type MFF 1/8 |
| 261636 | 91637 | Type MFF 1/8 |
| 261701 | 91637 | Type MFF 1/8 |
| 265744 | 89536 | 265744 |
| 266197 | 01121 | CB1625 |
| 266312 | 04713 | MC862P-6909 |
| 266478 | 74276 | A261 |
| 266494 | 89536 | 266494 |
| 266502 | 83594 | B5750S |
| 266619 | 07263 | 2N4888 |
| 267120 | 73445 | C280AE/A27K |
| 267138 | 91637 | Type MFF 1/8 |
| 267153 | 04713 | MC839P-6921 |
| 267211 | 89536 | 267211 |
| 267310 | 56289 | 30D205F150BB4 |
| 267336 | 01121 | CB1125 |
| 267393 | 91637 | Type MFF 1/8 |
| 267906 | 72982 | 532-000 |
| 267914 | 72982 | 532-001 |
| 268227 | 01121 | HB1051 |
| 268409 | 91637 | Type MFF 1/8 |
| 268714 | 83594 | SK207 |
| 268813 | 91637 | Type MFF 1/8 |
| 268862 | 71590 | J61993 |
| 268896 | 71590 | J52304 |
| 269639 | 89536 | 269639 |
| 269647 | 89536 | 269647 |
| 269688 | 89536 | 269688 |
| 269712 | 89536 | 269712 |
| 269761 | 89536 | 269761 |
| 269779 | 89536 | 269779 |

## MANUFACTURERS' CROSS REFERENCE LIST

| FLUKE STOCK NO. | MFR. | MFR. PART NO. |
|---|---|---|
| 269795 | 89536 | 269795 |
| 269803 | 89536 | 269803 |
| 269837 | 89536 | 269837 |
| 269886 | 89536 | 269886 |
| 271502 | 12040 | LM301A |
| 271494 | 83594 | B5853ST |
| 272237 | 07263 | 2N4946 |
| 272740 | 71450 | Type 115 |
| 272815 | 91637 | Type MMF 1/8 |
| 272823 | 91637 | Type MFF 1/8 |
| 272831 | 01121 | CB62G5 |
| 272922 | 83594 | B585-6ST |
| 274514 | 89536 | 274514 |
| 275354 | 89536 | 275354 |
| 275495 | 84411 | Type 663UW |
| 275552 | 32767 | 820-65 |
| 275560 | 32767 | 820-45 |
| 275578 | 32767 | 820-55 |
| 276527 | 23880 | TSA-2900-14W |
| 276535 | 23880 | TSA-2900-16W |
| 276618 | 91637 | Type MFF 1/8 |
| 276626 | 91637 | Type MFF 1/8 |
| 277004 | 00656 | HVD4150±20,3KV-2 |
| 279380 | 89536 | 279380 |
| 279372 | 89536 | 279372 |
| 279406 | 89536 | 279406 |
| 279422 | 89536 | 279422 |
| 279430 | 89536 | 279430 |
| 279448 | 89536 | 279448 |
| 284984 | 84613 | 3621-2 |
| 285593 | 89536 | 285593 |
| 286583 | 89536 | 286583 |
| 286708 | 89536 | 286708 |
| 287623 | 89536 | 287623 |
| 288324 | 15818 | U1994E |
| 288761 | 49956 | RS2048 |
| 289595 | 03508 | 1N4148 |
| 289991 | 91637 | Type MFF 1/8 |
| 290007 | 91637 | Type MFF 1/8 |
| 291039 | 89536 | 291039 |
| 306555 | 56289 | 500D305F250DC7 |

Section 6

# Option & Accessory Information

## 6-1. INTRODUCTION

6-2. This section of the manual contains information pertaining to the accessories and options available for your instrument.

## 6-3. OPTION INFORMATION

6-4. Each of the options available for this instrument, if any, are described separately under headings containing the option number. The option descriptions contain applicable operating and maintenance instructions and field installation procedures. A complete list of replaceable parts for each option is contained at the end of that option description.

## 6-5. ACCESSORY INFORMATION

6-6. The accessory information, if applicable, will contain details concerning accessories that may be used with this particular instrument.

# OPTION INFORMATION

## RECHARGEABLE BATTERY PACK KIT

### 6-1. INTRODUCTION

6-2. The rechargeable battery pack kit (Option 8100A-01K) may be factory installed when the instrument is first purchased or it may be purchased separately and installed at a later time as a kit. The kit consists of a rechargeable battery, a ballast lamp, two resistors, three diodes, a battery condition meter and associated hardware. The following paragraphs give the field installation procedure, operating instructions, and list of replaceable parts for the battery option kit.

### 6-3. INSTALLATION PROCEDURE

a. Disconnect the instrument from the line.

b. Remove the top and bottom dust covers, the narrow trim strips just above and below the readout tubes, and the top and bottom guards; use the procedure given in Section 4, paragraph 4-9 of the manual.

c. Install and solder the 2 ohm and 11.5k resistors on the PCB at the locations shown in Figure 6-1.

**CAUTION**

**Use a 40-watt soldering iron and non-corrosive solder on all connections.**

d. Install and solder the three diodes on the PCB at the locations shown in Figure 6-1. Be sure that the diodes are oriented according to the anode-cathode markings that are etched on the PCB.

e. Install and solder the ballast lamp on the PCB at the location shown in Figure 6-1. Three solder connections are required: The anchor lug on the component side of the PCB should be soldered to the side of the lamp base once the lamp is in position, and the two lamp terminals should be soldered from the underneath side of the PCB.

f. Refer to Figure 6-2 and install the meter by performing the following steps:

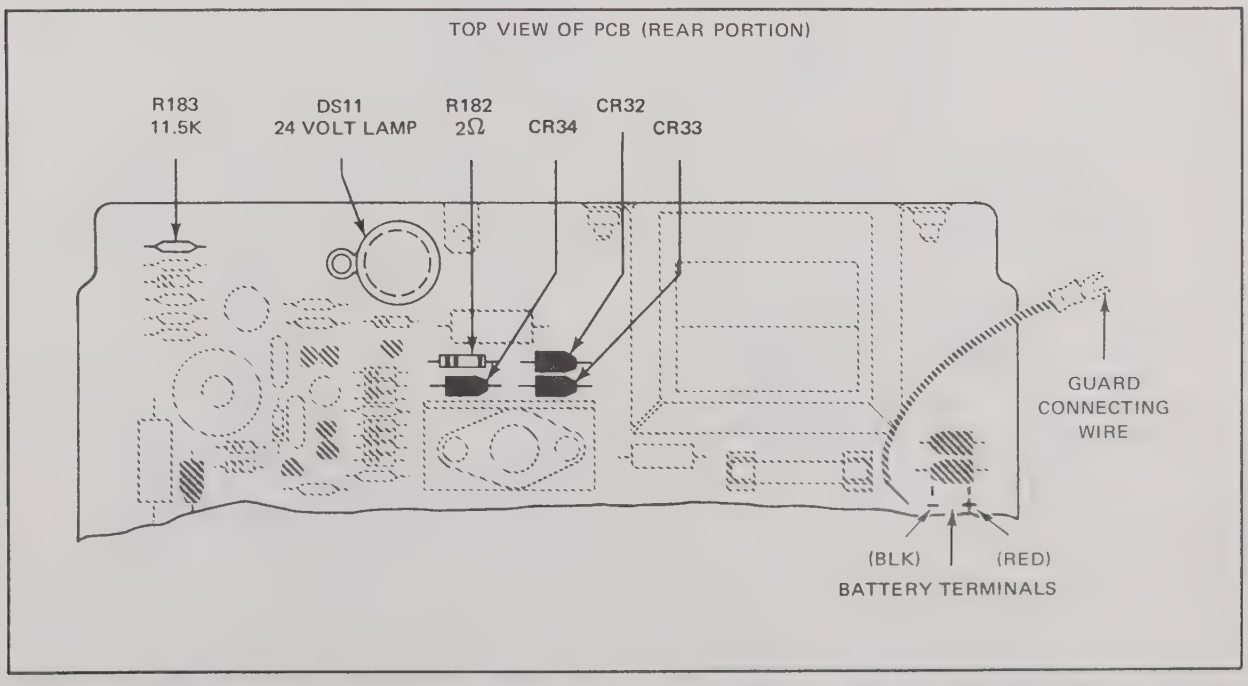



Figure 6-1. COMPONENT LOCATIONS FOR MODEL 8100A-01K BATTERY OPTION KIT INSTALLATION

1. Remove the nut and two washers which fasten the black tube cover to the inside of the front panel assembly near the INPUT terminals.

2. Remove the meter cover from the front panel; install the meter with the meter face in position against the front panel.

3. Fasten the cover in place by replacing the nut and washers.

4. Bend the meter lugs toward the rear so they are parallel with the PCB and aligned with holes in PCB. See Figure 6-2.

5. Connect each meter lug to hole in PCB directly under parallel bent meter lugs using suitable length of tinned #22AWG copper wire. Solder each of four connections securely in place.

g. On underside of top guard, remove shield. See Figure 6-3. Install the battery pack on the underneath side of the top guard, using the battery pack holder and the six machine screws (Figure 6-3). Orient the battery pack so the grommeted battery leads pass through the grommet hole in the edge of the guard.

h. Replace the top guard and connect the battery leads to BATTERY TERMINAL pins at the right-rear of the PCB as shown in Figure 6-1. Red lead to + terminal and black lead to other terminal.

i. Replace the bottom guard and top and bottom covers.

## 6-4. OPERATING INSTRUCTIONS

6-5. The battery supplies power to the instrument whenever the instrument is disconnected from the line. The front panel meter monitors the charge condition of the batteries during battery operation BAT OK. During line operation, while the batteries are charging, the meter indicates LINE OPR (full scale). When fully charged, the batteries will provide 8 hours of continuous operation before recharging is necessary. When fully discharged, the batteries will require a maximum of 10 hours to fully charge.

6-6. The ballast lamp, DS11, provides constant current charge even though line and battery levels may vary.

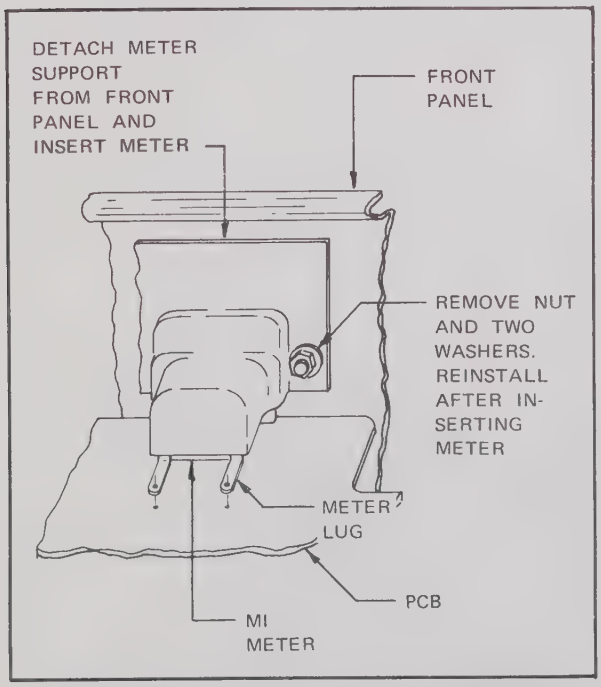

DETACH METER SUPPORT FROM FRONT PANEL AND INSERT METER
FRONT PANEL
REMOVE NUT AND TWO WASHERS. REINSTALL AFTER INSERTING METER
METER LUG
PCB
MI METER

Figure 6-2. BATTERY OPTION KIT METER INSTALLATION.

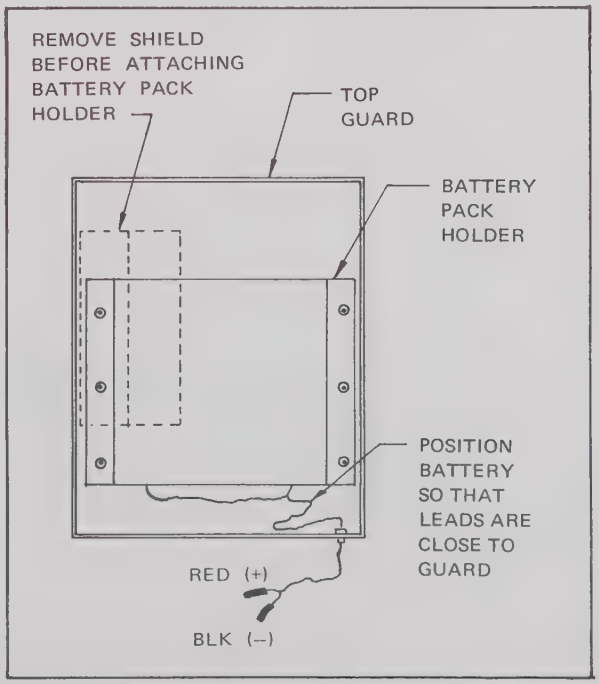

REMOVE SHIELD BEFORE ATTACHING BATTERY PACK HOLDER
TOP GUARD
BATTERY PACK HOLDER
POSITION BATTERY SO THAT LEADS ARE CLOSE TO GUARD
RED (+)
BLK (–)

Figure 6-3. BATTERY OPTION KIT BATTERY INSTALLATION.

| REF DESIG | DESCRIPTION | STOCK NO | TOT QTY | REC QTY | USE CODE |
|---|---|---|---|---|---|
| | **DIGITAL MULTIMETER – KIT, BATTERY OPTION *** | 8110A-01K | | | |
| BT1 | Battery Pack | 269837 | 1 | | |
| M1 | Meter, 0-1 ma | 266494 | 1 | | |
| XBT1 | Holder, battery pack | 269712 | 1 | | |
| — | Wire, bus tinned copper #22AWG | 115469 | 1 | | |
| — | Screw, FHMS, undercut 6-32 x 1/4 | 268169 | 6 | | |
| | Add the following components to the Printed Circuit Assembly (A1): | | | | |
| CR32, CR33 | Diode, silicon, 1 amp, 600 piv | 112383 | 2 | | |
| CR34 | Diode, silicon, 1 amp, 100 piv | 116111 | 1 | | |
| DS11 | Lamp, incandescent, 24v | 218354 | 1 | 2 | |
| R182 | Res, comp, 2Ω ±5%, ½w | 218735 | 1 | | |
| R183 | Res, met flm, 11.5k ±1%, 1/8w | 267138 | 1 | | |

* Option Kit, part number 269886

# OPTION INFORMATION

## PRINTER OUTPUT UNIT

### 6-1. INTRODUCTION

6-2. The Printer Output Unit (POU) provides data output that is completely isolated from the analog input and is available in 8-4-2-1 BCD logic level format. Data is transferred serially via guarded transformers from the multimeter to the POU. Digit, range, function, filter, and overrange data are provided.

### 6-3. SPECIFICATIONS

### 6-4. Electrical Specifications

| | |
|---|---|
| DATA PROVIDED | Digits, range, function, and filter. |
| CODING | BCD Digits, four lines for range, individual lines for functions and filter. |
| LOGIC LEVELS | "1" = 2.4V @ 0.4 ma load (3.5V maximum, open terminal) |
| | "0" = 0.4V maximum at 13 ma sink (0V no load) |
| TRIGGER DESCRIPTION | Positive or negative true triggering via two trigger channels using either a pulse or a steady state logic signal. |
| | Channel 1 |
| Pulse Width | >300 ns |
| Transition | Logic "0" to logic "1" |
| Logic "1" | >2.7V @ 360 ua max. |
| Logic "0" | <0.6V @ no drain |
| Continuous Sample | Logic "1" |
| Input Definition | TTL (UTILOGIC II SERIES) |
| | Chanel 2 |
| | >300 ns |
| | Logic "1" to logic "0" >2.0V (4.7k pull up resistor) on input. |
| | <0.8V @ 3.2 ma sink |
| | Logic "0" |
| | TTL (7400 SERIES) |
| PRINT COMMAND | Change of state from logic "1" to logic "0" and change of state from logic "0" to logic "1" are both provided. |

### 6-5. Mechanical Specifications

| | |
|---|---|
| OUTPUT CONNECTOR | 36-pin Amphenol 57-40360 |
| | JF Part Number 158469 |
| MATING CONNECTOR | 36-pin Amphenol 57-30360 |
| | JF Part Number 158451 |

## 6-6. General Specifications

Code conversion and level translation are available; contact the factory for details.

Option –02 is a factory installed option and is not compatible with battery option.

Full CMRR specifications of a line operated 8100 series digital multimeter are met. Maximum potential between printer output common and power line ground is 250V dc or peak ac.

## 6-7. INSTALLATION

6-8. The Printer Output Unit is a factory installed option.

## 6-9. OPERATING INSTRUCTIONS

## 6-10. Description

6-11. The POU enables the multimeter to interface with a computer, printer, or a variety of data recording systems. POU access is by means of a single rear-mounted 36-pin connector. Connector location and pin assignments are given in Figure 6-1. The unit is self-powered. POU truth table is given in Table 6-1.

Table 6-1. POU TRUTH TABLE

| DATA | NO. OF LINES | LOGIC LEVEL | |
|---|---|---|---|
| | | LOGIC "0" 0 TO 0.4V | LOGIC "1" 2.4 TO 3.5V |
| Function: VDC, VAC, KΩ, 10 MΩ, FILTERS | 5 | Function not called. | Function called. |
| Polarity (logic "0" for all functions except "+VDC") | 1 | Negative | Positive |
| Range: 1, 10, 100 and 1000 | 4 | Range not called. | Range called. |
| Digits: 8-4-2-1 BCD | 16 | Binary "0" | Binary "1" |
| Overrange Digit | 1 | Not overranged. | *Overranged. |

* 11999 readout should be interpreted as "overranged and overloaded".

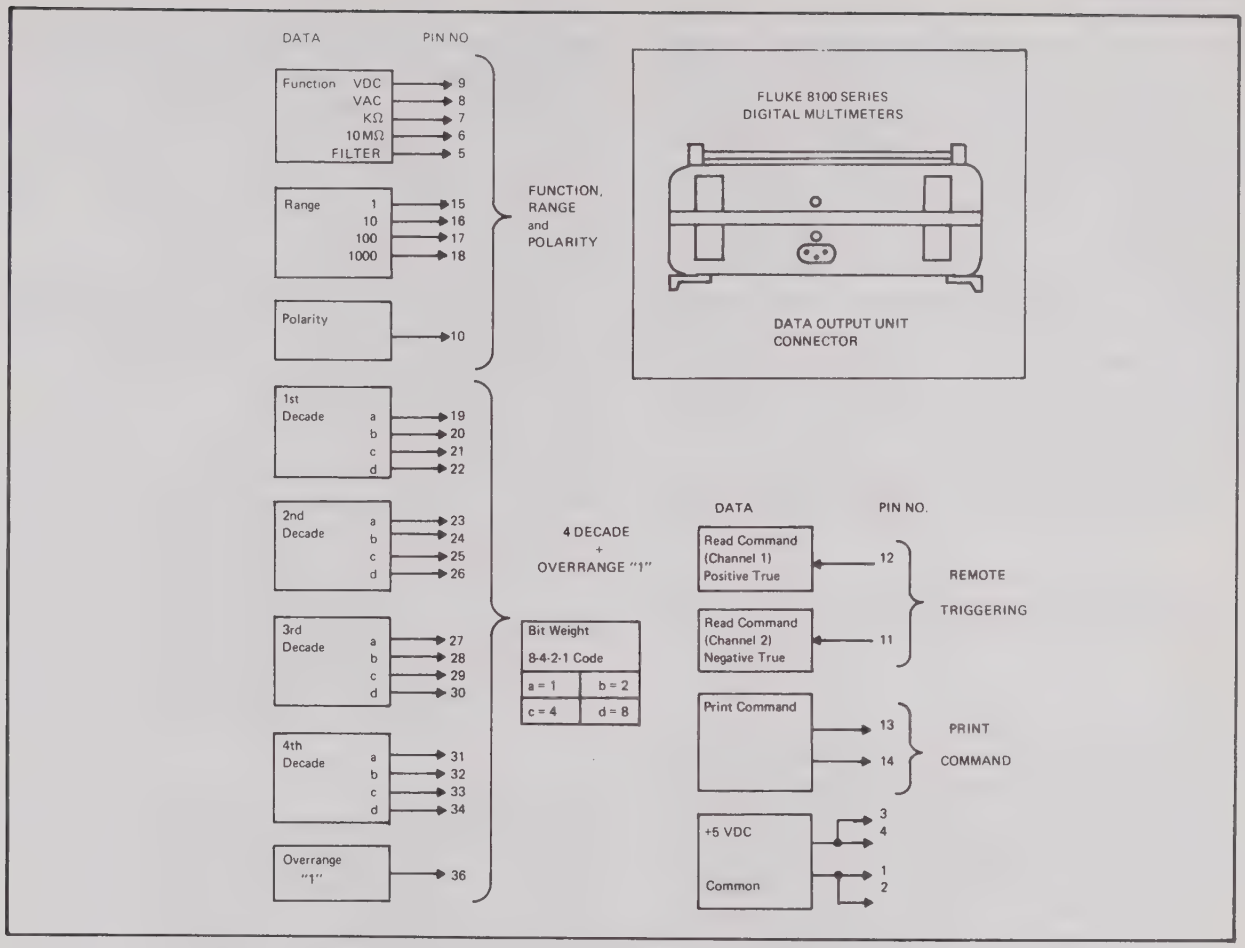



Figure 6-1. PRINTER OUTPUT UNIT CONNECTOR LOCATION AND PIN ASSIGNMENT

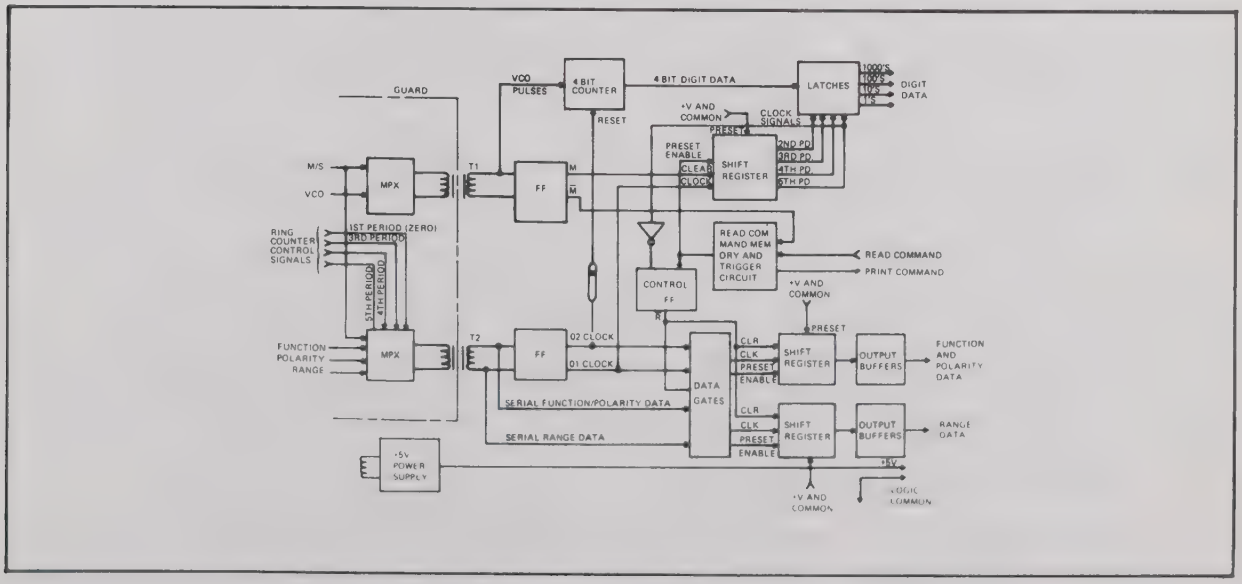



Figure 6-2. PRINTER OUTPUT UNIT BLOCK DIAGRAM

6-12. The Printer Output Unit can be triggered by either a positive true or negative true read command. The read command may be either a pulse or a steady state logic level. If triggered by a pulse, the unit will provide data derived from a sample of the multimeter input within 450 milliseconds of the read command. This data will be stored in the output register until the next read command is received. If triggered by a continuous logic level, data in the output resister will be updated approximately every 400 milliseconds, as often as the instrument makes a measurement). Characteristics of the read command signal are given in Table 6-2.

*NOTE!*

*The measurement cycle of the instrument is not altered by the read command.*

## 6-13. THEORY OF OPERATION

### 6-14. General

6-15. The Printer Output Unit accepts multimeter measurement information, multiplexes it for serial transmission through the guard and enters this data into circuitry which provides BCD (8-4-2-1) decade outputs and function, polarity, and uncoded range outputs. A digital memory, comprised of four bistable latches provides 4-line, BCD digital data. A pair of 5-bit shift registers function as a serial in-parallel out memory for multimeter function, function, polarity, and range data. The POU block diagram is shown in Figure 6-2.

### 6-16. Multiplexer

6-17. Multimeter function, range, polarity, and digit inputs together with logic control signals are applied to multiplexer circuitry consisting of transistors Q1 through Q13 and NOR gates A1 and A2.

6-18. VCO pulses are applied to one input of dual-input NOR gate A1–A, and the measure/store signal is applied to the other input. The VCO pulses enable the gate and its output is applied to the trigger circuit composed of Q5 and T1. The VCO pulses are coupled into the secondary of T1 (signal (1))and applied to counter A10. Trigger pulses corresponding to the measure/store signal are produced by Q2, Q3, and Q5 in the primary of T1. The measure/store signal is reconstructed by flip-flop A4–C, D from the secondary of T1, producing M and $\overline{M}$ signals.

6-19. Multimeter clock signals, $\phi 1$ and $\phi 2$, are applied to trigger circuits Q11 and Q13, respectively. The trigger pulses are coupled into the secondary of T2 where they alternately set and reset flip-flop A4–A, B, producing reconstructed clock signals 3 and 4.

Table 6-2. READ COMMAND SIGNAL REQUIREMENTS

| READ COMMAND | CHANNEL | |
|---|---|---|
| | 1 | 2 |
| TRIGGER: Pulse Width | >300 ns | >300 ns |
| Rise Time | | |
| Transition | Logic "0" to logic "1" | Logic "1" to logic "0" |
| LOGIC LEVEL: Logic "1" | >2.7V at 360 ua max. | >2.0V (4.7k pull-up resistor) on input. |
| Logic "0" | <0.6V at no drain | <0.8V at 3.2 ma sink |
| CONTINUOUS SAMPLE | Logic "1" | Logic "0" |
| INPUT DEFINITION | TTL (UTILOGIC II SERIES) | TTL (7400 SERIES) |

6-20. The Ø1 clock signal is also applied to a one-shot, A1–B, D. The one-shot provides a delay for entry of function and polarity data into the trigger circuit to ensure that data pulses are not obscured by clock pulses. Function inputs (KΩ, VAC, 10MΩ, and FILTer) are controlled by FET buffers Q6 through Q9, which are sequentially enabled by ring counter signals corresponding to periods 1 (zeroing period), 3, 4, and 5 of the measurement cycle. If one or more of these functions are called, a low will appear at one input of NOR gate A1–C during the appropriate period of the measurement cycle; the one-shot, which controls the other input of gate A1–C, will time out, and A1–C will provide a pulse to the trigger circuit. The polarity input is NORed with the one-shot output in A2–C and is also delayed.

6-21. The Ø2 clock signal is applied to one-shot A2–A, B to provide a delay for range inputs. Range information is derived from the readout tube decimal point circuitry and is applied to transistor Q12 in the multiplexer. Inverted range data is then applied to gate A2–D. After the prescribed delay, it enters the trigger circuit of Q13 and T2. The Printer Output Unit timing diagram is shown in Figure 6-3.

## 6-22. Digit Count and Memory Circuitry

6-23. Four-Bit counter A-10 accepts VCO pulses from Inverter A2-F and produces a 4-line BCD output corresponding to digit value. The counter is reset at the beginning of each digitizing period by a delayed reset pulse (signal 7 ), which is derived from the Ø2 clock signal. This delay duplicates the delay of the multimeter counter reset pulse so that the counters are sychronized. The reset pulse is produced by NOR gate A12–B, transistor Q4, and associated components.

6-24. The BCD output of A10, representing digit value in a 4-line code, is applied to two dual 4-bit bistable latches, A6 and A7. The latches are clocked by signals from A11, a 5-bit shift register. The clock signals appear at the input of the latches sequentially, beginning with the 2nd period of the measurement cycle. BCD information corresponding to the most significant digit is transferred to the output of the latches first and BCD outputs for the three remaining digits follow in order. The latches provide 4-line BCD storage for each digit.

6-25. Overrange indication is provided by AND gate A1–D which provides a logical "1" output whenever the first digit is 10 or more. Gates A1–A, B prevent the register from indicating greater than "9" for the first digit.

6-26. Shift register A11 is cleared at the start of the storage cycle by the M signal, setting all shift register outputs to the logical "0" state: the register remains in this state for the duration of the storage cycle. The read pulse (signal 12 ), developed by the read command circuit, is applied to the preset enable input of the shift register; this pulse only occurs if an external trigger has been stored in flip-flop A5–C,D prior to the M signal. The preset input sets output 15 (pin 15) of A11 to the logical "1" state. The Ø1 clock signal is applied to the clock input of the register; and the next transistion of this clock signal from logical "1" to logical "0", occurring at the start of the 2nd period, shifts the register and provides a logical "1" at output 14 (pin 14) of the register. Succeeding clock signal transisitions cause continued shift of the register until output 10 switches to the logical "1" state, which causes the read command and control flip-flops to be reset.

## 6-27. Read Command Memory and Trigger Circuit

6-28. Positive read command pulses or logic levels appear at pin 11 of flip-flop A5–C, D. Negative read commands appear at the same input after inversion in A2-3B. The positive input sets the flip-flop, producing a low at one input of dual input NOR gate A12–C. Circuit conditions will hold until the start of the measurement cycle, at which time the negative transition of the M signal causes A12–C to produce the read pulse (signal 12 ). This sets CONTROL flip-flop A5–A, B clearing A8 & A9 and enabling A3–B, A3–C and A12–D to allow transmission of Function and Range information to shift registers A8 and A9. At the end of the measure cycle, flip-flops A5–C, D A5–A, B will be reset by the output of gate A12–A, producing negative and positive print commands, and storing range and function data by disabling clock pulses. from A12–D to A8 and A9.

## 6-29. Function, Polarity, and Range Circuitry

6-30. Serial function and polarity data is applied to gate A3–C and serial range data is applied to gate A3–B. Each gate is controlled by one phase of the clock signal and a signal from control flip-flop A5–A, B. Function and polarity data appear as positive pulses at the preset enable input of A8 during the digitizing period (Ø1) of the clock. Range data appears as positive pulses at the preset enable input of A9 during the display period (Ø2) of the clock.

6-31. Shift registers A8 and A9 are cleared at the beginning of each measure cycle by the control flip-flop if a read pulse has been initiated. The registers are clocked at

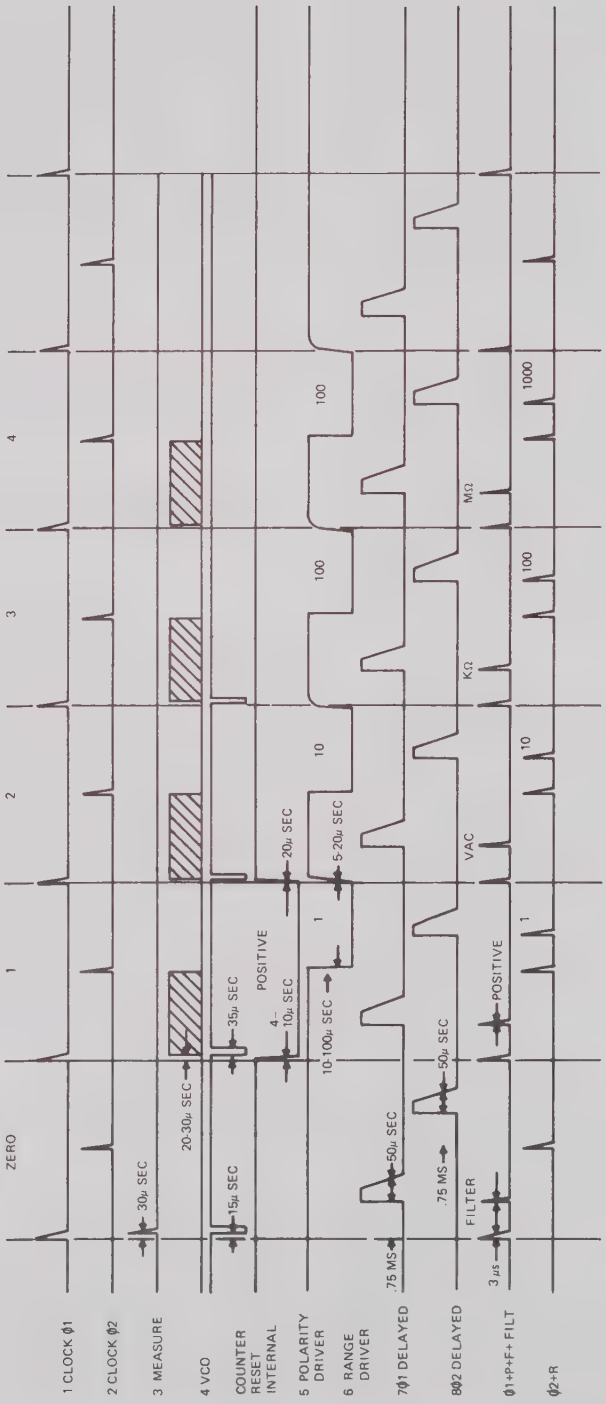



Figure 6-3. TIMING DIAGRAM

the beginning of the digitizing period of the clock by the signal from gate A12-D. Each data pulse at the input of the registers presets a logical "1" at output 15 of the registers and the clock pulses shift the registers five times each measure cycle, resulting in correct data positions at the output.

6-32. AND gates A13, and A14 are output buffer gates. NOR gate A3–A provides a logical "1" output when VDC function is called; it also enables AND gate A1–C for polarity indication.

## 6-33. MAINTENANCE

### 6-34. General

6-35. General maintenance information, such as factory service and instrument cleaning procedures, is covered in Section 4 of the manual. The following information covers service procedures peculiar to the POU.

### 6-36. Access/Disassembly

6-37. POU circuitry is located on two separate PCBs. The POU Output Assembly PCB contains all POU circuitry located outside the multimeter guard and the POU Encoder Assembly contains all POU circuitry located inside the guard. The following procedure should be used to gain access to POU circuitry (Refer to Figure 6-4.):

a. To gain access to the POU Output Assembly, remove the top dust cover. The assembly is mounted to the top of the guard chassis.

b. To gain access to the POU Encoder Assembly, remove the four guard chassis mounting screws located on the side rails and carefully lift the guard chassis out of the multimeter to the extent permitted by the POU wiring. The POU Encoder Assembly is mounted on the underneath side of the guard chassis.

c. To replace components on either PCB, remove the PCB mounting hardware to gain access to the soldered side of the board.

### 6-38. POU/Multimeter Wiring

6-39. All POU/Multimeter connections are made with pin connectors. The wires are color coded and the coding is indicated on the wiring diagram so that leads which are disconnected may be replaced correctly.

### 6-40. Test Equipment

6-41. Equipment required for testing, troubleshooting, and calibration of the POU is given in Table 6-3.

Table 6-3. TEST EQUIPMENT

| EQUIPMENT NOMENCLATURE | RECOMMENDED EQUIPMENT | FUNCTION |
|---|---|---|
| DC Voltage Source | Fluke Model 343A DVM Calibrator | Performance Tests and Troubleshooting |
| DC Voltmeter | Model 8100A Digital Multimeter | Troubleshooting |
| Oscilloscope | Tektronix Type 545A Oscilloscope with Type 1A1 Dual Trace Plug-In | Troubleshooting |

### 6-42. Performance Tests

6-43. Correct operation of the Printer Output Unit can be verified by applying various inputs to the multimeter and observing the POU outputs on a printer or other recording device. Refer to Section II of the manual for operating instructions and equipment connections.

### 6-44. Troubleshooting

6-45. Before attempting to troubleshoot the unit, it should be verified that the trouble is actually in the POU and is not caused by faulty external equipment. As a first step, the POU should be exercised as described in "Performance Tests" to determine what fault is present. Once the fault is identified, consult the troubleshooting guide, Figure 6-5, as an aid in making a troubleshooting decision.

6-46. Check POU waveforms with an oscilloscope. Sync the scope with the Ø2 clock signal. Refer to the POU timing diagram, Figure 6-3, for correct signal timing.

## 6-47. CALIBRATION

6-48. No calibration is required in the POU.

## 6-49. PARTS LIST

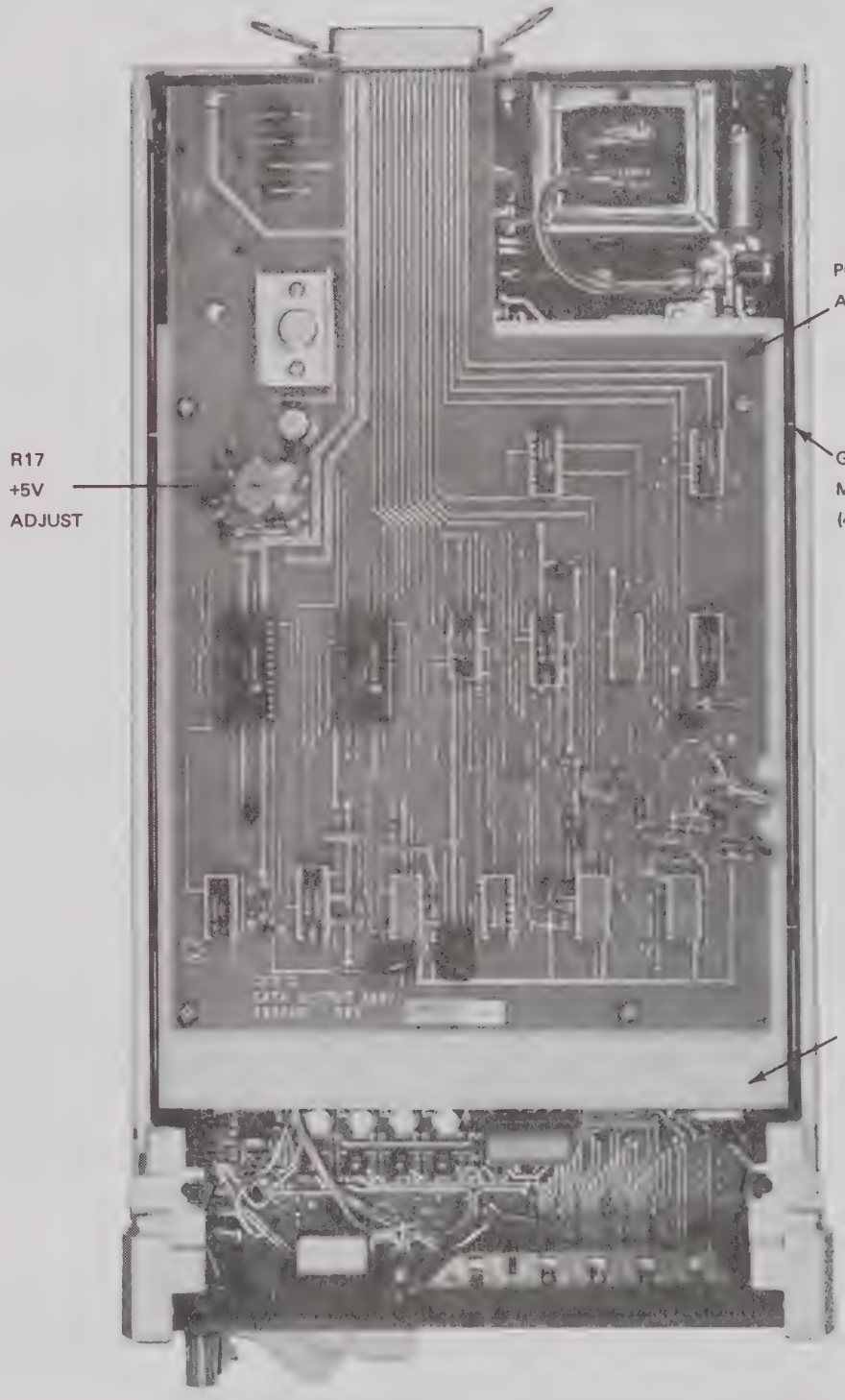



Figure 6-4. PRINTER OUTPUT UNIT PCB LOCATION (Sheet 1)

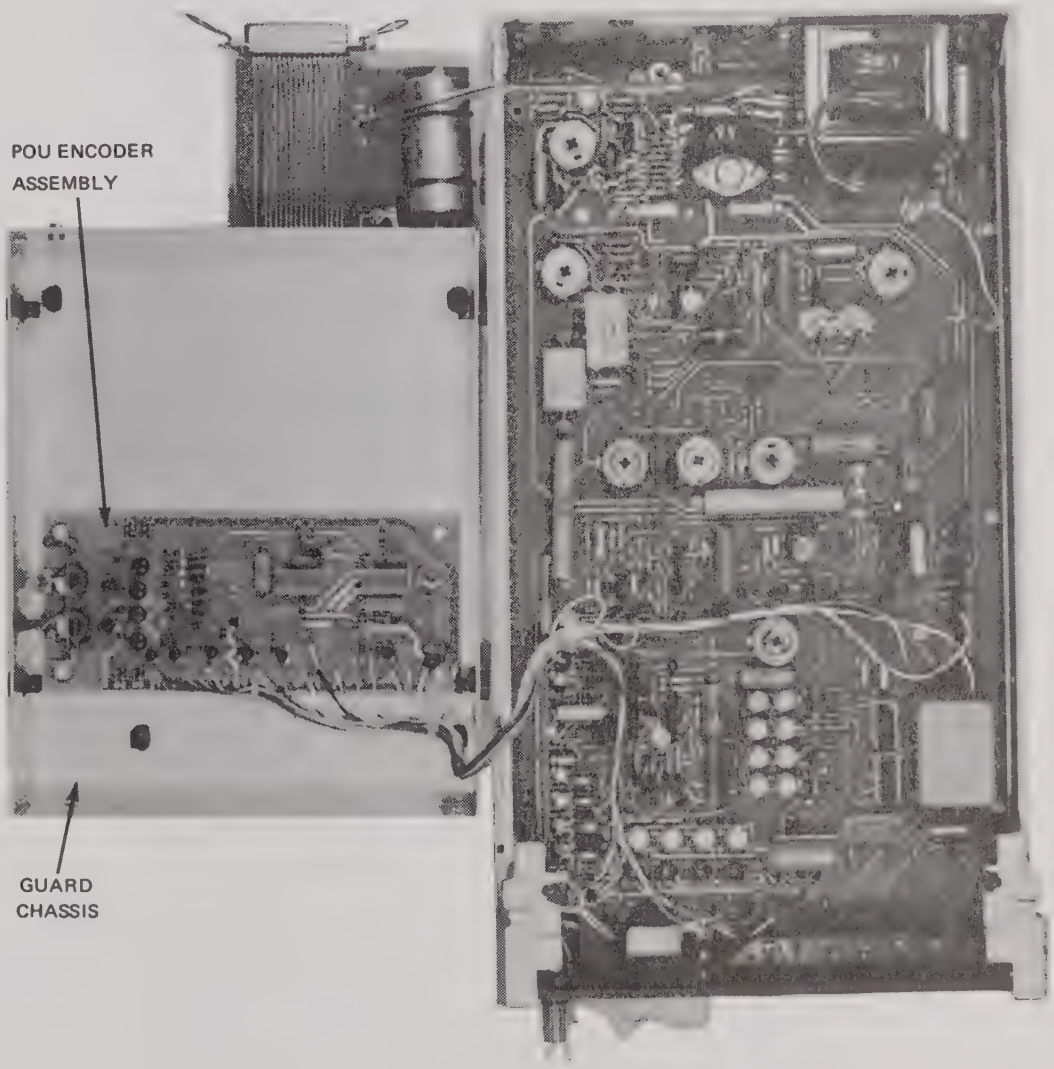



Figure 6-4. PRINTER OUTPUT UNIT PCB LOCATION (Sheet 2)

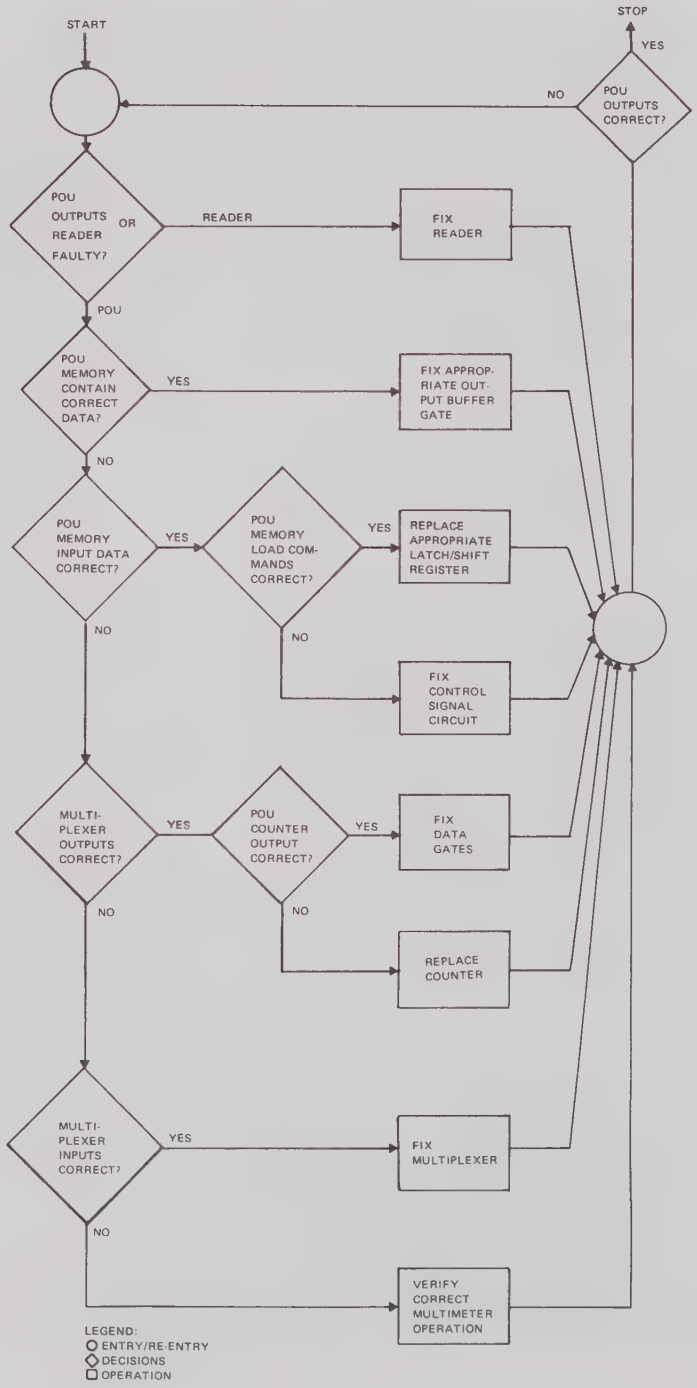



Figure 6-5. POU TROUBLESHOOTING GUIDE

| REF DESIG | INDEX NO | DESCRIPTION | STOCK NO | MFR | MFR PART NO | TOT QTY | REC QTY | USE CODE |
|---|---|---|---|---|---|---|---|---|
| | | **DIGITAL MULTIMETER–ISOLATED PRINTER OUTPUT OPTION** | 8100A-02 | | | | | |
| | | CHANGE: | | | | | | |
| T101 | | Transformer, power from: | 275354 | 89536 | 275354 | 1 | | |
| | | to: | 295881 | 89536 | 295881 | 1 | | |
| | | ADD: | | | | | | |
| A2 | | DATA OUTPUT PCB ASSEMBLY (See Figure 6-6) | 295808 | 89536 | 295808 | 1 | | |
| A3 | | DATA OUTPUT ENCODER PCB ASSEMBLY (See Figure 6-7) | 294793 | 89536 | 294793 | 1 | | |

| REF DESIG | INDEX NO | DESCRIPTION | STOCK NO | MFR | MFR PART NO | TOT QTY | REC QTY | USE CODE |
|---|---|---|---|---|---|---|---|---|
| A2 | | DATA OUTPUT PCB ASSEMBLY Figure 6-6 | 295808 | 89536 | 295808 | REF | | |
| A1 | E1-01 | IC, TTL, Quad 2-Input + AND Gates | 292987 | 01295 | SN7408N | 3 | | |
| A2 | B5-02 | IC, TTL, Hex Inverter | 292979 | 01295 | SN7404N | 1 | | |
| A3 | E1-P3 | IC, TTL, Triple 3-Input Nor Gate | 268565 | 18324 | SP370A | 1 | | |
| A4 | B5-P5 | IC, TTL, Quad 2-Input Nor Gate | 268540 | 18324 | SP380A | 3 | | |
| A5 | B5-P1 | IC, TTL, Quad 2-Input Nor Gate | 268540 | 18324 | SP380A | REF | | |
| A6 | D5-N2 | IC, TTL, 8-Bit Latch | 288837 | 01295 | SN74100N | 2 | | |
| A7 | D5-M1 | IC, TTL, 8-Bit Latch | 288837 | 01295 | SN74100N | REF | | |
| A8 | E1-04 | IC, TTL, 5-Bit Shift Register | 293399 | 01295 | SN7496N | 3 | | |
| A9 | E1-Q1 | IC, TTL, 5-Bit Shift Register | 293399 | 01295 | SN7496N | REF | | |
| A10 | B5-L5 | IC, DTL, Binary Counter | 267153 | 04713 | MC839P | 1 | | |
| A11 | B5-M4 | IC, TTL, 5-Bit Shift Register | 293399 | 01295 | SN7496N | REF | | |
| A12 | B5-N3 | IC, TTL, Quad 2-Input Nor Gate | 268540 | 18324 | SP380A | REF | | |
| A13 | F4-O4 | IC, TTL, Quad 2-Input + AND Gates | 292987 | 01295 | SN7408N | REF | | |
| A14 | F4-Q1 | IC, TTL, Quad 2-Input + AND Gates | 292987 | 01295 | SN7408N | REF | | |
| C1 | B2-N3 | Cap, mica, 5600 pf ±2%, 500V | 182873 | 14655 | CD19F562G | 2 | | |
| C2 | B3-N5 | Cap, mica, 5600 pf ±2%, 500V | 182873 | 14655 | CD19F562G | REF | | |
| C3 | C3-N1 | Cap, plstc, 0.022 uf ±10%, 250V | 234484 | 73445 | C280AE/A22K | 3 | | |
| C4 | B4-N2 | Cap, cer, 0.0012 uf ±10%, 500V | 106732 | 71590 | CF122 | 2 | | |
| C5 | C5-P2 | Cap, cer, 0.0012 uf ±10%, 500V | 106732 | 71590 | CF122 | REF | | |
| C6 | D3-P5 | Cap, mica, 220 pf ±5%, 500V | 170423 | 14655 | CD15F221J | 1 | | |
| C7 | C3-P5 | Cap, plstc, 0.022 uf ±10%, 250V | 234484 | 73445 | C280AE/A22K | REF | | |
| C8 | C4-P4 | Cap, plstc, 0.022 uf ±10%, 250V | 234484 | 73445 | C280AE/A22K | REF | | |
| C9 | H4-L5 | Cap, elect, 3800 uf +75/-10%, 15V (mounted on back) | 276758 | 56289 | 196D106X0015 | 1 | | |
| C10 | F4-M3 | Cap, Ta, 10 uf ±20%, 15V | 193623 | 56289 | 196D106X0015 | 5 | | |
| C11 | E5-05 | Cap, Ta, 10 uf ±20%, 15V | 193623 | 56289 | 601D388G015JL4 | REF | | |
| C12 | C4-M1 | Cap, Ta, 10 uf ±20%, 15V | 193623 | 56289 | 196D106X0015 | REF | | |

| REF DESIG | INDEX NO | DESCRIPTION | STOCK NO | MFR | MFR PART NO | TOT QTY | REC QTY | USE CODE |
|---|---|---|---|---|---|---|---|---|
| C14 | E2-Q2 | Cap, cer, 0.01 uf ±20%, 100V | 149153 | 56289 | C023B101F103M | 2 | | |
| C15 | C1-O5 | Cap, mica, 100 pf ±5%, 500V | 148494 | 14655 | CD15F101J | 1 | | |
| C16 | B4-N1 | Cap, cer, 0.01 uf ±20%, 100V | 149153 | 56289 | C023B101F103M | REF | | |
| C17 | F3-L5 | Cap, Ta, 10 uf ±20%, 15V | 193623 | 56289 | 196D106X0015 | REF | | |
| C18 | C3-P1 | Cap, Ta, 10 uf ±20%, 15V | 193623 | 56289 | 196D106X0015 | REF | | |
| CR1 | C4-Q1 | Diode, germanium, 80 ma, 100 piv | 149187 | 93332 | IN270 | 5 | | |
| CR2 | C2-Q2 | Diode, germanium, 80 ma, 100 piv | 149187 | 93332 | IN270 | REF | | |
| CR3 | C4-Q3 | Diode, germanium, 80 ma, 100 piv | 149187 | 93332 | IN270 | REF | | |
| CR4 | D1-Q3 | Diode, germanium, 80 ma, 100 piv | 149187 | 93332 | IN270 | REF | | |
| CR5 | B4-O5 | Diode, germanium, 80 ma, 100 piv | 149187 | 93332 | IN270 | REF | | |
| CR6 | I4-M2 | Diode, silicon, 1 amp, 100 piv | 116111 | 05277 | IN4817 | 4 | | |
| CR7 | I2-M2 | Diode, silicon, 1 amp, 100 piv | 116111 | 05277 | IN4817 | REF | | |
| CR8 | I4-M2 | Diode, silicon, 1 amp, 100 piv | 116111 | 05277 | IN4817 | REF | | |
| CR9 | I3-M2 | Diode, silicon, 1 amp, 100 piv | 116111 | 05277 | IN4817 | REF | | |
| CR10 | F2-M2 | Diode, zener, 3.9V | 113316 | 07910 | IN748 | 1 | | |
| J1 | J2-N3 | Connector, female, 36 contact | 158469 | 02660 | 57-40360 | 1 | | |
| Q1 | H3-M4 | Tstr, silicon, NPN (mounted on back) | 288381 | 95303 | 40372 | 1 | | |
| Q2 | G1-M3 | Tstr, silicon, NPN | 150359 | 95303 | 2N3053 | 1 | | |
| Q3 | F2-L5 | Tstr, silicon, NPN | 168708 | 03508 | 2N3391 | 1 | | |
| Q4 | B4-M2 | Tstr, silicon, NPN | 218396 | 04713 | 2N3904 | 1 | | |
| R1 | C2-P5 | Res, comp, 240 Ω ±5%, ¼w | 221895 | 01121 | CB2415 | 4 | | |
| R2 | C3-Q3 | Res, comp, 240 Ω ±5%, ¼w | 221895 | 01121 | CB2415 | REF | | |
| R3 | D2-Q2 | Res, comp, 240 Ω ±5%, ¼w | 221895 | 01121 | CB2415 | REF | | |
| R4 | C4-Q2 | Res, comp, 240 Ω ±5%, ¼w | 221895 | 01121 | CB2415 | REF | | |
| R5 | B5-M1 | Res, comp, 2.2k ±5%, ¼w | 148049 | 01121 | CB2225 | 4 | | |
| R6 | C1-N5 | Res, comp, 3.3k ±5%, ¼w | 148056 | 01121 | CB3325 | 1 | | |
| R7 | C4-N3 | Res, comp, 3.9k ±5%, ¼w | 148064 | 01121 | CB3925 | 1 | | |
| R8 | C4-P2 | Res, comp, 2.7k ±5%, ¼w | 170720 | 01121 | CB2725 | 2 | | |

| REF DESIG | INDEX NO | DESCRIPTION | STOCK NO | MFR | MFR PART NO | TOT QTY | REC QTY | USE CODE |
|---|---|---|---|---|---|---|---|---|
| R9 | C4-O5 | Res, comp, 2.7k ±5%, ¼w | 170720 | 01121 | CB2725 | REF | | |
| R10 | D1-O4 | Res, comp, 4.7k ±5%, ¼w | 148072 | 01121 | CB4725 | 1 | | |
| R11 | D1-O5 | Res, comp, 15k ±5%, ¼w | 148114 | 01121 | CB1535 | 1 | | |
| R12 | D4-Q2 | Res, comp, 1k ±5%, ¼w | 148023 | 01121 | CB1025 | 3 | | |
| R13 | C2-P5 | Res, comp, 2.2k ±5%, ¼w | 148049 | 01121 | CB2225 | REF | | |
| R14 | C4-P3 | Res, comp, 2.2k ±5%, ¼w | 148049 | 01121 | CB2225 | REF | | |
| R15 | F5-L5 | Res, comp, 2k ±5%, ¼w | 202879 | 01121 | CB2025 | 3 | | |
| R16 | G2-M3 | Res, comp, 5.6k ±5%, ¼w | 148080 | 01121 | CB5625 | 2 | | |
| R17 | F3-M2 | Res, var, comp, 1k ±30%, ¼w | 281642 | 71450 | Type U201 | 1 | | |
| R18 | F1-M1 | Res, met flm, 182 Ω ±1%, 1/8w | 200030 | 91637 | RN55D1820F | 1 | | |
| R19 | B5-M2 | Res, comp, 2k ±5%, ¼w | 202879 | 01121 | CB2025 | REF | | |
| R20 | C1-N1 | Res, comp, 5.6k ±5%, ¼w | 148080 | 01121 | CB5625 | REF | | |
| R21 | D1-P2 | Res, comp, 8.2k ±5%, ¼w | 160796 | 01121 | CB8225 | 1 | | |
| R22 | D4-Q1 | Res, comp, 1k ±5%, ¼w | 148023 | 01121 | CB1025 | REF | | |
| R23 | B5-O5 | Res, comp, 1k ±5%, ¼w | 148023 | 01121 | CB1025 | REF | | |
| R24 | C3-N4 | Res, comp, 2.2k ±5%, ¼w | 148049 | 01121 | CB2225 | REF | | |
| R25 | F4-L5 | Res, comp, 2k ±5%, ¼w | 202879 | 01121 | CB2025 | REF | | |
| R27 | B2-N1 | Res, comp, 1.5k ±5%, ¼w | 148031 | 01121 | CB1525 | 1 | | |
| R28 | B2-M3 | Res, var, ww, 1k ±20%, 1¼w | 111575 | 71450 | Type 110 | 1 | | |
| | | Socket, IC, 14 contact | 276527 | 23880 | TSA-2900-14W | 9 | | |
| | | Socket, IC, 16 contact | 276535 | 23880 | TSA-2900-16W | 3 | | |
| | | Socket, IC, 24 contact | 292946 | 71785 | 24 DIP | 2 | | |

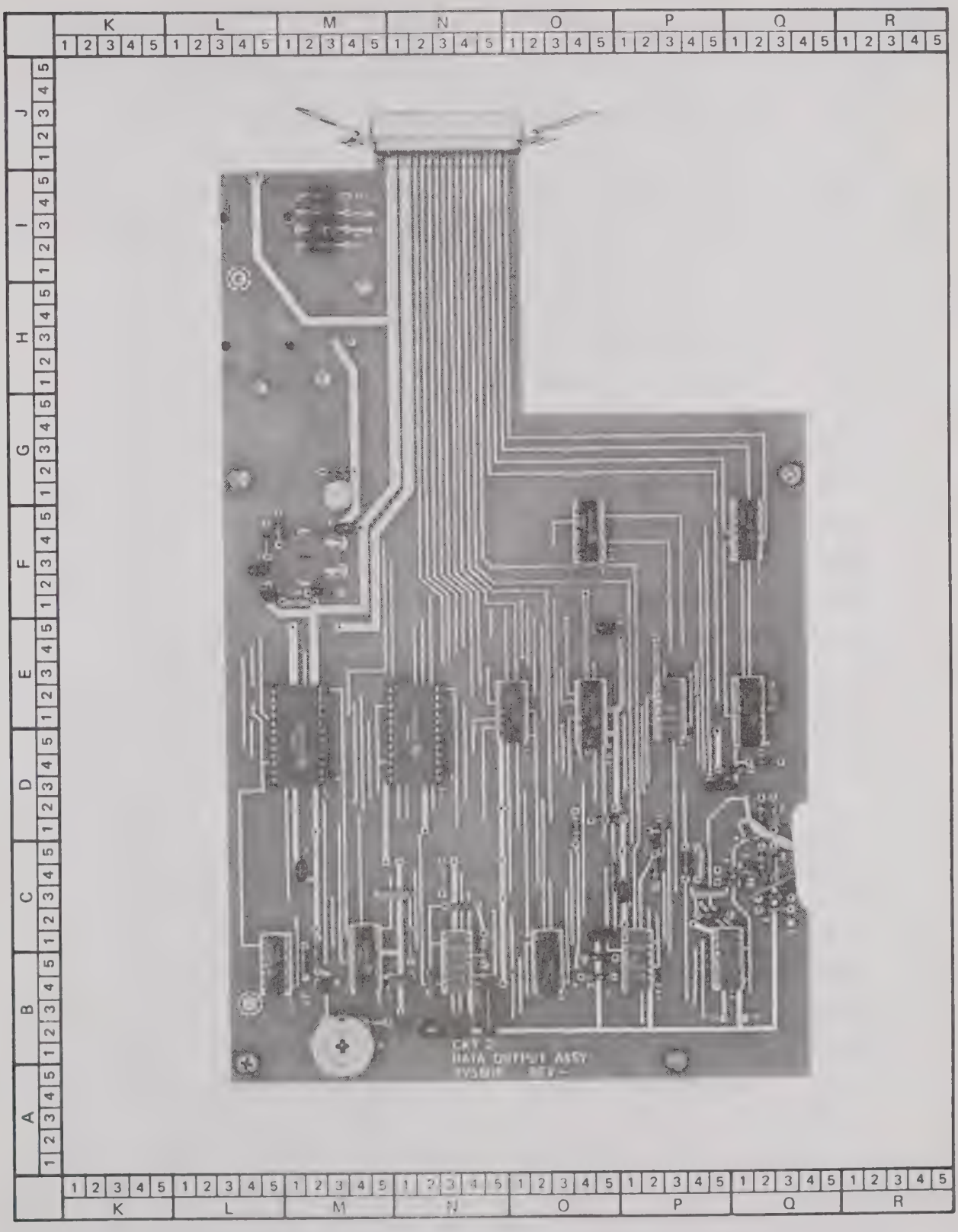


Figure 6-6. DATA OUTPUT PCB ASSEMBLY

| REF DESIG | INDEX NO | DESCRIPTION | STOCK NO | MFR | MFR PART NO | TOT QTY | REC QTY | USE CODE |
|---|---|---|---|---|---|---|---|---|
| A3 | | DATA OUTPUT ENCODER PCB ASSEMBLY<br>Figure 6-7 | 294793 | 89536 | 294793 | REF | | |
| A1 | E1-O3 | IC, TTL, Quad 2-Input Nor Gate | 268540 | 18324 | SP380A | 2 | | |
| A2 | C1-O3 | IC, TTL, Quad 2-Input Nor Gate | 268540 | 18324 | SP380A | REF | | |
| C1 | A5-M5 | Cap, Ta, 10 uf ±20%, 15V | 193623 | 56289 | 196D106X0015 | 3 | | |
| C2 | G4-N3 | Cap, cer, 0.0012 uf ±10%, 500V | 106732 | 71590 | CF122 | 8 | | |
| C3 | G2-N4 | Cap, cer, 0.0012 uf ±10%, 500V | 106732 | 71590 | CF122 | REF | | |
| C4 | G1-N5 | Cap, cer, 0.0012 uf ±10%, 500V | 106732 | 71590 | CF122 | REF | | |
| C5 | D2-P2 | Cap, cer, 0.01 uf ±20%, 100V | 149153 | 56289 | C023B101F103M | 2 | | |
| C6 | E5-O4 | Cap, plstc, 0.22 uf ±10%, 80V | 159392 | 56289 | 192P2249R8 | 2 | | |
| C7 | D5-O5 | Cap, cer, 0.05 uf ±20%, 100V | 149161 | 56289 | 55C23A1 | 3 | | |
| C8 | G2-O5 | Cap, cer, 0.0012 uf ±10%, 500V | 106732 | 71590 | CF122 | REF | | |
| C9 | G2-04 | Cap, cer, 0.0012 uf ±10%, 500V | 106732 | 71590 | CF122 | REF | | |
| C10 | G2-P1 | Cap, cer, 0.0012 uf ±10%, 500V | 106732 | 71590 | CF122 | REF | | |
| C11 | A5-N2 | Cap, cer, 0.05 uf ±20%, 100V | 149161 | 56289 | 55C23A1 | REF | | |
| C12 | B3-N5 | Cap, cer, 0.01 uf ±20%, 100V | 149153 | 56289 | C023B101F103M | REF | | |
| C13 | C2-N5 | Cap, plstc, 0.22 uf ±10%, 80V | 159392 | 56289 | 192P2249R8 | REF | | |
| C14 | B5-O5 | Cap, cer, 0.05 uf ±20%, 100V | 149161 | 56289 | 55C23A1 | REF | | |
| C15 | G2-O3 | Cap, cer, 0.0012 uf ±10%, 500V | 106732 | 71590 | CF122 | REF | | |
| C16 | G2-O1 | Cap, cer, 0.0012 uf ±10%, 500V | 106732 | 71590 | CF122 | REF | | |
| C17 | I1-N3 | Cap, Ta, 10 uf ±20%, 15V | 193623 | 56289 | 196D106X0015 | REF | | |
| C18 | I1-O4 | Cap, Ta, 10 uf ±20%, 15V | 193623 | 56289 | 196D106X0015 | REF | | |
| CR1 | I2-M3 | Diode, silicon, 150 ma | 203323 | 03508 | DHD1105 | 6 | | |
| CR2 | H5-M3 | Diode, silicon, 150 ma | 203323 | 03508 | DHD1105 | REF | | |
| CR3 | C5-N1 | Diode, silicon, 150 ma | 203323 | 03508 | DHD1105 | REF | | |
| CR4 | H2-P3 | Diode, silicon, 150 ma | 203323 | 03508 | DHD1105 | REF | | |
| CR5 | C3-N1 | Diode, silicon, 150 ma | 203323 | 03508 | DHD1105 | REF | | |

| REF DESIG | INDEX NO | DESCRIPTION | STOCK NO | MFR | MFR PART NO | TOT QTY | REC QTY | USE CODE |
|---|---|---|---|---|---|---|---|---|
| CR6 | H4-P3 | Diode, silicon, 150 ma | 203323 | 03508 | DHD1105 | REF | | |
| Q1 | H2-M5 | Tstr, FET, N-channel | 288324 | 15818 | U1994E | 6 | | |
| Q2 | H3-N4 | Tstr, silicon, NPN | 182196 | 07263 | 2N3643 | 4 | | |
| Q3 | F3-N4 | Tstr, silicon, NPN | 218396 | 04713 | 2N3904 | 3 | | |
| Q5 | H3-N1 | Tstr, silicon, NPN | 182196 | 07263 | 2N3643 | REF | | |
| Q6 | E2-M5 | Tstr, FET, N-channel | 288324 | 15818 | U1994E | REF | | |
| Q7 | F1-M5 | Tstr, FET, N-channel | 288324 | 15818 | U1994E | REF | | |
| Q8 | F5-M5 | Tstr, FET, N-channel | 288324 | 15818 | U1994E | REF | | |
| Q9 | G4-M5 | Tstr, FET, N-channel | 288324 | 15818 | U1994E | REF | | |
| Q10 | B5-N1 | Tstr, FET, N-channel | 288324 | 15818 | U1994E | REF | | |
| Q11 | H3-O5 | Tstr, silicon, NPN | 182196 | 07263 | 2N3643 | REF | | |
| Q12 | B1-O3 | Tstr, silicon, NPN | 218396 | 04713 | 2N3904 | REF | | |
| Q13 | H3-O2 | Tstr, silicon, NPN | 182196 | 07263 | 2N3643 | REF | | |
| Q14 | H3-M4 | Tstr, silicon, NPN | 218396 | 04713 | 2N3904 | REF | | |
| R1 | H1-N2 | Res, comp, 1k ±5%, ¼w | 148023 | 01121 | CB1025 | 3 | | |
| R2 | G5-N4 | Res, comp, 470 Ω ±5%, ¼w | 147983 | 01121 | CB4715 | 1 | | |
| R3 | I3-M3 | Res, comp, 4.7k ±5%, ¼w | 148072 | 01121 | CB4725 | 11 | | |
| R4 | I1-N5 | Res, comp, 47 Ω ±5%, ¼w | 147892 | 01121 | CB4705 | 4 | | |
| R5 | F4-N2 | Res, comp, 4.7k ±5%, ¼w | 148072 | 01121 | CB4725 | REF | | |
| R6 | G1-N3 | Res, comp, 1.2k ±5%, ¼w | 190371 | 01121 | CB1225 | 2 | | |
| R11 | G4-N5 | Res, comp, 1k ±5%, ¼w | 148023 | 01121 | CB1025 | REF | | |
| R12 | I1-M3 | Res, comp, 4.7k ±5%, ¼w | 148072 | 01121 | CB4725 | REF | | |
| R13 | I1-N2 | Res, comp, 47 Ω ±5%, ¼w | 147892 | 01121 | CB4705 | REF | | |
| R14 | C4-N3 | Res, comp, 4.7k ±5%, ¼w | 148072 | 01121 | CB4725 | REF | | |
| R15 | E3-N1 | Res, comp, 20k ±5%, ¼w | 221614 | 01121 | CB2035 | 4 | | |

| REF DESIG | INDEX NO | DESCRIPTION | STOCK NO | MFR | MFR PART NO | TOT QTY | REC QTY | USE CODE |
|---|---|---|---|---|---|---|---|---|
| R16 | F2-N1 | Res, comp, 20k ±5%, ¼w | 221614 | 01121 | CB2035 | REF | | |
| R17 | G1-N1 | Res, comp, 20k ±5%, ¼w | 221614 | 01121 | CB2035 | REF | | |
| R18 | G3-N1 | Res, comp, 20k ±5%, ¼w | 221614 | 01121 | CB2035 | REF | | |
| R19 | D5-P3 | Res, comp, 4.7k ±5%, ¼w | 148072 | 01121 | CB4725 | REF | | |
| R20 | C4-N1 | Res, comp, 2.2k ±5%, ¼w | 148049 | 01121 | CB2225 | 2 | | |
| R21 | D5-N5 | Res, comp, 6.8k ±5%, ¼w | 148098 | 01121 | CB6825 | 2 | | |
| R22 | D5-P1 | Res, comp, 2.7k ±5%, ¼w | 170720 | 01121 | CB2725 | 2 | | |
| R23 | G5-O5 | Res, comp, 750 Ω ±5%, ¼w | 218024 | 01121 | CB7515 | 2 | | |
| R24 | G5-O4 | Res, comp, 910 Ω ±5%, ¼w | 203851 | 01121 | CB9115 | 1 | | |
| R25 | B4-N2 | Res, comp, 4.7k ±5%, ¼w | 148072 | 01121 | CB4725 | REF | | |
| R26 | G5-P1 | Res, comp, 750 Ω ±5%, ¼w | 218024 | 01121 | CB7515 | REF | | |
| R27 | H3-P3 | Res, comp, 4.7k ±5%, ¼w | 148072 | 01121 | CB4725 | REF | | |
| R28 | I1-O5 | Res, comp, 47 Ω ±5%, ¼w | 147892 | 01121 | CB4705 | REF | | |
| R29 | B3-O4 | Res, comp, 4.7k ±5%, ¼w | 148072 | 01121 | CB4725 | REF | | |
| R30 | B2-O1 | Res, comp, 4.7k ±5%, ¼w | 148072 | 01121 | CB4725 | REF | | |
| R31 | C2-N1 | Res, comp, 2.2k ±5%, ¼w | 148049 | 01121 | CB2225 | REF | | |
| R32 | C2-N4 | Res, comp, 6.8k ±5%, ¼w | 148098 | 01121 | CB6825 | REF | | |
| R33 | C3-O5 | Res, comp, 2.7k ±5%, ¼w | 170720 | 01121 | CB2725 | REF | | |
| R34 | G5-O3 | Res, comp, 1k ±5%, ¼w | 148023 | 01121 | CB1025 | REF | | |
| R35 | G5-O1 | Res, comp, 1.2k ±5%, ¼w | 190371 | 01121 | CB1225 | REF | | |
| R36 | H5-P3 | Res, comp, 4.7k ±5%, ¼w | 148072 | 01121 | CB4725 | REF | | |
| R37 | I1-O2 | Res, comp, 47 Ω ±5%, ¼w | 147892 | 01121 | CB4705 | REF | | |
| R38 | E1-P3 | Res, comp, 10k ±5%, ¼w | 148106 | 01121 | CB1035 | 2 | | |
| R39 | C2-P3 | Res, comp, 10k ±5%, ¼w | 148106 | 01121 | CB1035 | REF | | |
| R40 | G5-N1 | Res, comp, 4.7k ±5%, ¼w | 148072 | 01121 | CB4725 | REF | | |
| T1 | I5-N2 | Transformer, pulse | 275362 | 01121 | 275362 | 2 | | |
| T2 | I5-O2 | Transformer, pulse | 275362 | 01121 | 275362 | REF | | |
| | | Socket, IC, 14 contact | 276527 | 23880 | TSA-2900-14W | 2 | | |

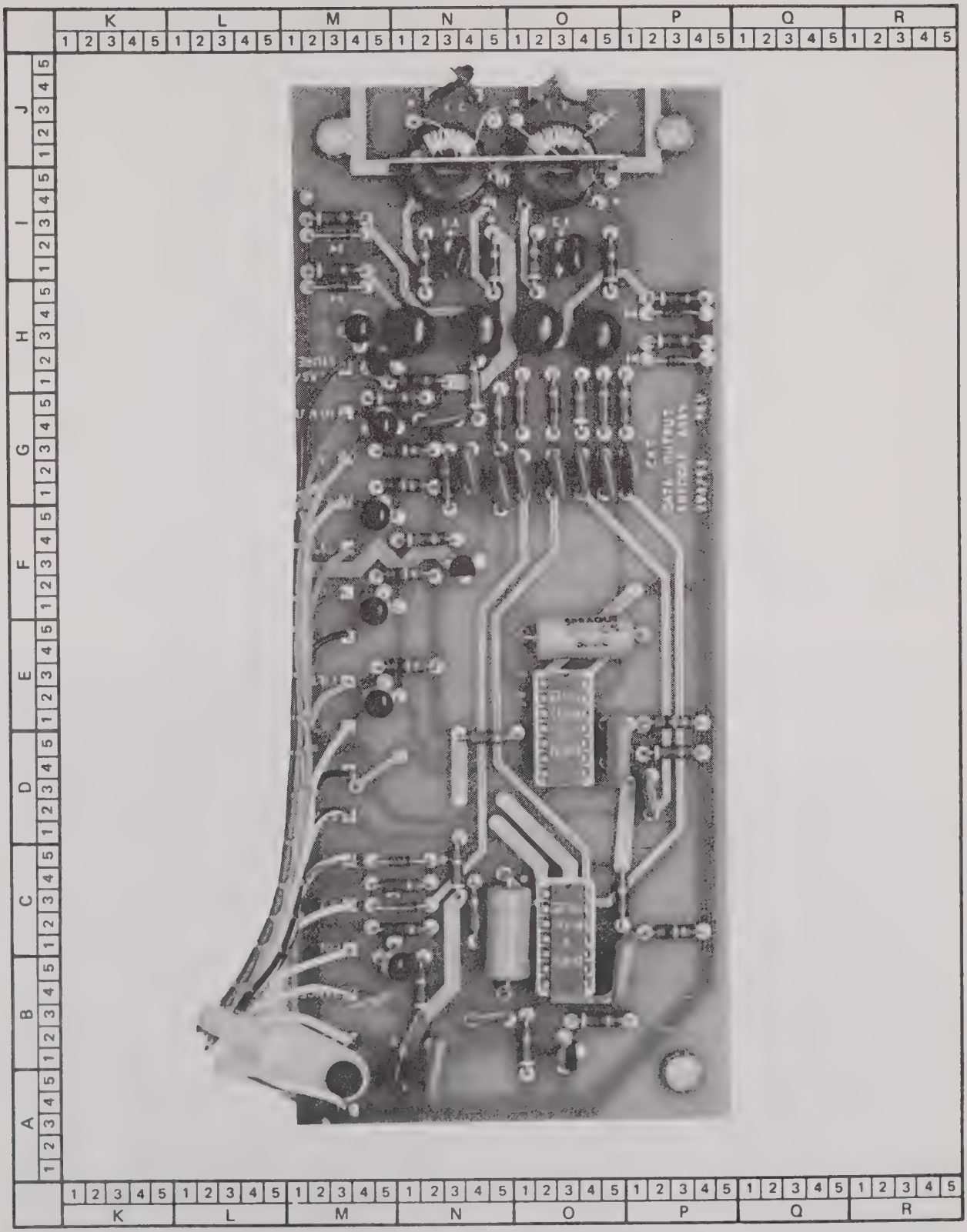
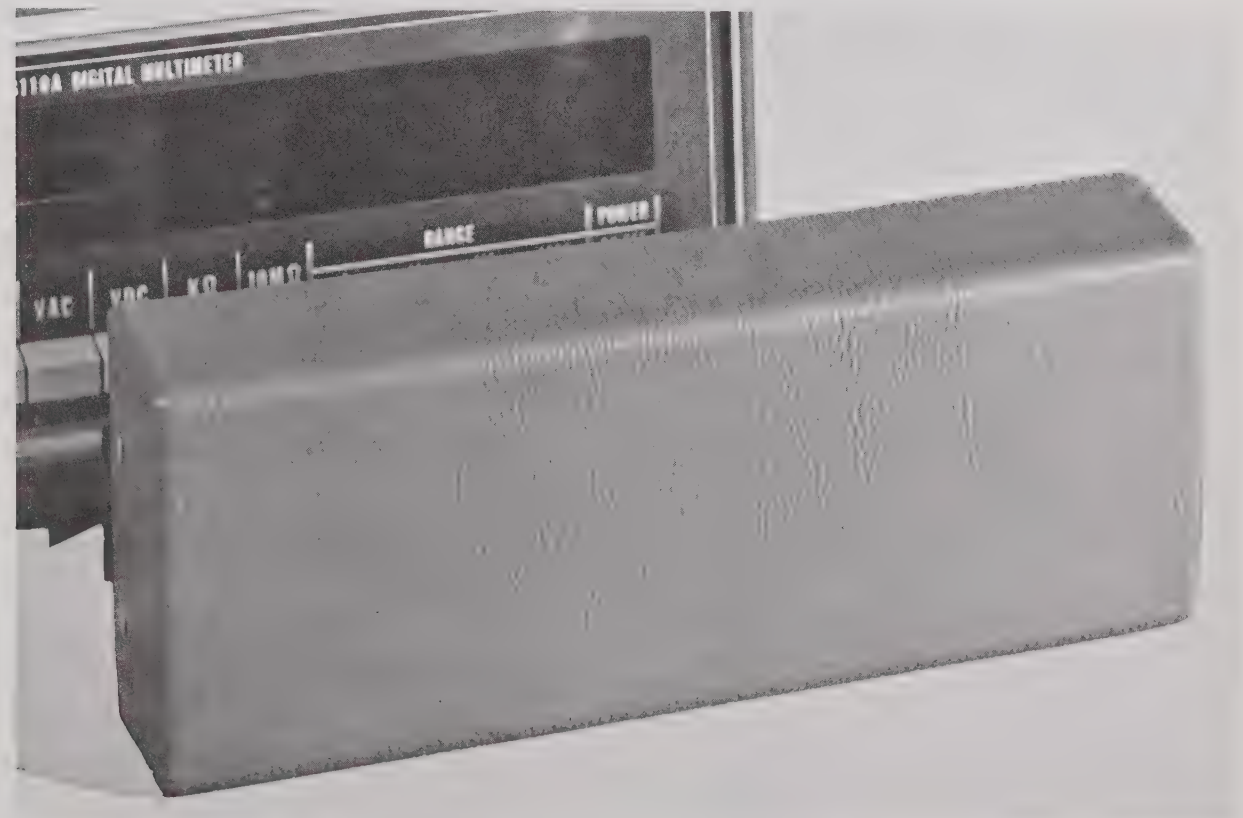



Figure 6-7. DATA OUTPUT ENCODER PCB ASSEMBLY

# ACCESSORY INFORMATION

## FRONT PANEL DUST COVER

6-1. The vacuum-formed dust cover (Fig. 6-1) attaches to the front of the instrument. It prevents accumulation of dust on the front panel when the instrument is not in use and it affords added protection for the instrument when it is in transit. Order number for the dust cover is MEE-4008.



# ACCESSORY INFORMATION

## RACK MOUNTS

6-1. There are three rack mount kits available for this instrument.

6-2. Kit MEE-7014 allows two half-rack instruments to be mounted side-by-side in a standard 19-inch rack. The two instruments are connected together at the center of the rack by two number ten machine screws (not supplied). Holes for these screws are located in the front casting and are accessible after removing the decal at the side of the casting. The rack ears fasten to the front casting at either side and are each held in place by two existing screws located under the decal.

6-3. Kit MEE-6006 supplies the hardware necessary to mount one instrument in the center of the rack. In this kit the rack ears are proportionally longer than those in MEE-7014 to permit center mounting, but are attached in the same manner.

6-4. Kit MEE-7013 provides two different size rack ears so that a single instrument can be mounted to the left or right of rack center.

# ACCESSORY INFORMATION

## MODEL 80-RF HIGH FREQUENCY PROBE

## 6-1. INTRODUCTION

62. The Model 80-RF High Frequency Probe allows measurements over a frequency range of 100 kHz to 500 MHz from 0.25 to 30 volts when using FLUKE voltmeters having an input impedance of 10 megohms ±10%. The accuracy of measurement is ±5% from 100 kHz to 100 MHz and +7% to 500 MHz. The probe operates into any dc voltmeter having an input impedance of 10 megohms ±10%. A shielded dual-banana plug on the probe permits direct connection to the voltmeter input.

## 6-3. SPECIFICATIONS

## 6-4. Electrical

**VOLTAGE** 0.25V to 30V

**RESPONSE:** Responds to peak value of input. Calibrated to read rms value of a sine wave input.

**AC TO DC TRANSFER ACCURACY:**
Loaded with 10 megohms ±10%.

| | 100 KHz – 100 MHz | 100 MHz – 500 MHz |
|---|---|---|
| +10°C to +30°C | ±5% | ±7% |
| –10°C to +40°C | ±7% | ±15% |

<±3 db at 10 kHz and 700 MHz.

**INPUT IMPEDANCE:** 4 megohms shunted by 2 ±0.5 pf.

**MAXIMUM INPUT:** 30 volts rms AC, 200 volts DC.

## 6-5. General

**CABLE CONNECTIONS:** Shielded dual banana plug
Fits all standard 3/4-inch dual banana connectors.

**CABLE LENGTH:** 4 ft(121.9 cm) minimum.

**WEIGHT:** 3-½ oz. net.

**ACCESSORIES SUPPLIED**
Ground Lead
Straight Tip
Hook Tip
High Frequency Adapter

## 6-6. OPERATING INSTRUCTIONS

6-7. Connect the shielded dual banana plug directly to the voltmeter input terminals, GND to COMMON or LO. Affix the appropriate probe tip to the probe body, then connect the probe to the high frequency circuit under test. When using the Straight or Hook Tip the ground clip must be connected to the test circuit. When using the high frequency adaptor with appropriate 50 ohm connectors, the ground clip is not required.

6-8. The Straight Tip or Hook Tip supplied with the probe can be used for measurements up to 100 MHz. For measurements above 100 MHz the High Frequency Adapter allows connections to 50 ohm terminations. Ensure that the probe is used in conjunction with dc voltmeters having 10 MΩ ±10% input impedance to meet its specifications.

6-9. The maximum input to the probe is 30 volts rms ac, or 200 volts dc. These factors may be used in combination so that an ac signal may be measured riding on a dc voltage of up to 200 volts. However, it must be noted that if ac superimposed on dc is being measured, the dc level must not be changed by more than 200 volts or the resulting transient is apt to damage the diodes inside the probe.

## 6-10. THEORY OF OPERATION

6-11. Figure 6-1 contains a schematic diagram of the probe. C1 is a dc blocking capacitor, CR1 is used as a detector, and R1, R3, CR2, R2, and Rin form a divider network. C1, charging through CR1 during the negative half cycle of the input produces a positive dc voltage at the CR1-R1 junction which equals the negative peak value of the input signal. The divider network reduces this to the rms value of the input. It can be seen that the probe must be operated into a 10 MΩ load in order to maintain the proper division ratio.

6-12. CR2 provides compensation for the non-linearity of the detector. R3 is a selected part having a value of 50 kΩ to 100 kΩ, as required for proper divider action.

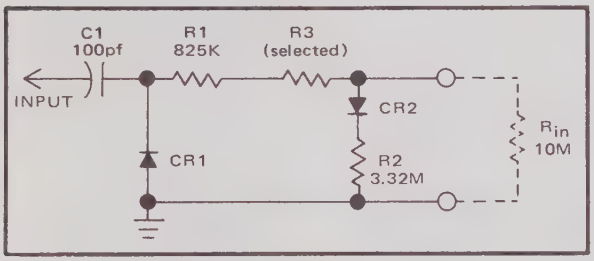



Figure 6-1. SCHEMATIC

## 6-13. MAINTENANCE

### 6-14. Performance Checks

6-15. The following checks verify the probe AC to DC Transfer accuracy.

6-16. LOW FREQUENCY RESPONSE. Connect equipment as shown in Figure 6-2, and perform the following steps.

a. With equipment as shown in connection "A" adjust the ac signal source for an output of 3.000 volts rms at 100 kHz as measured on the DVM.

b. In connection "B" with the DVM set to measure dc, observe a probe output of 3.15 to 2.85 volts.

c. Placing cables back in connection "A", decrease the ac signal source by 10db (0.95 volts).

d. Moving back to connection "B", observe a voltmeter indication of between 1.00 and 0.90 volts (10 db down from 3 volts).

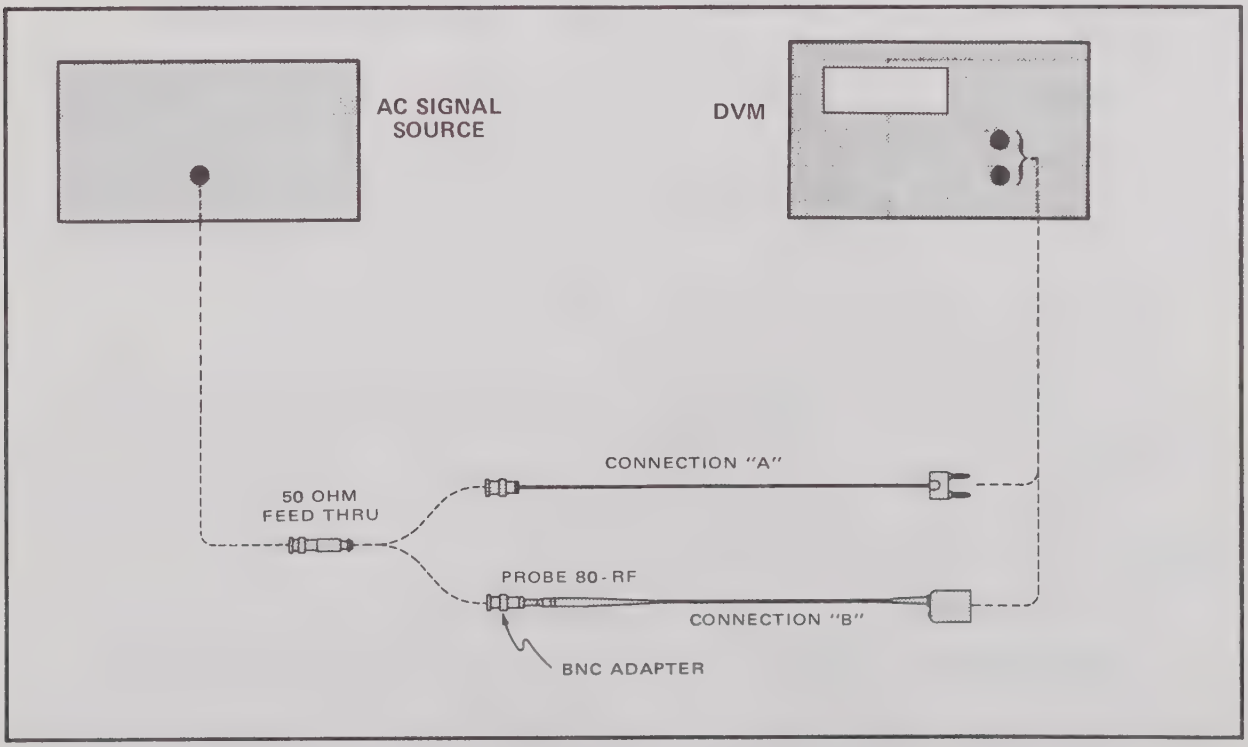



Figure 6-2. LOW FREQUENCY RESPONSE CHECK

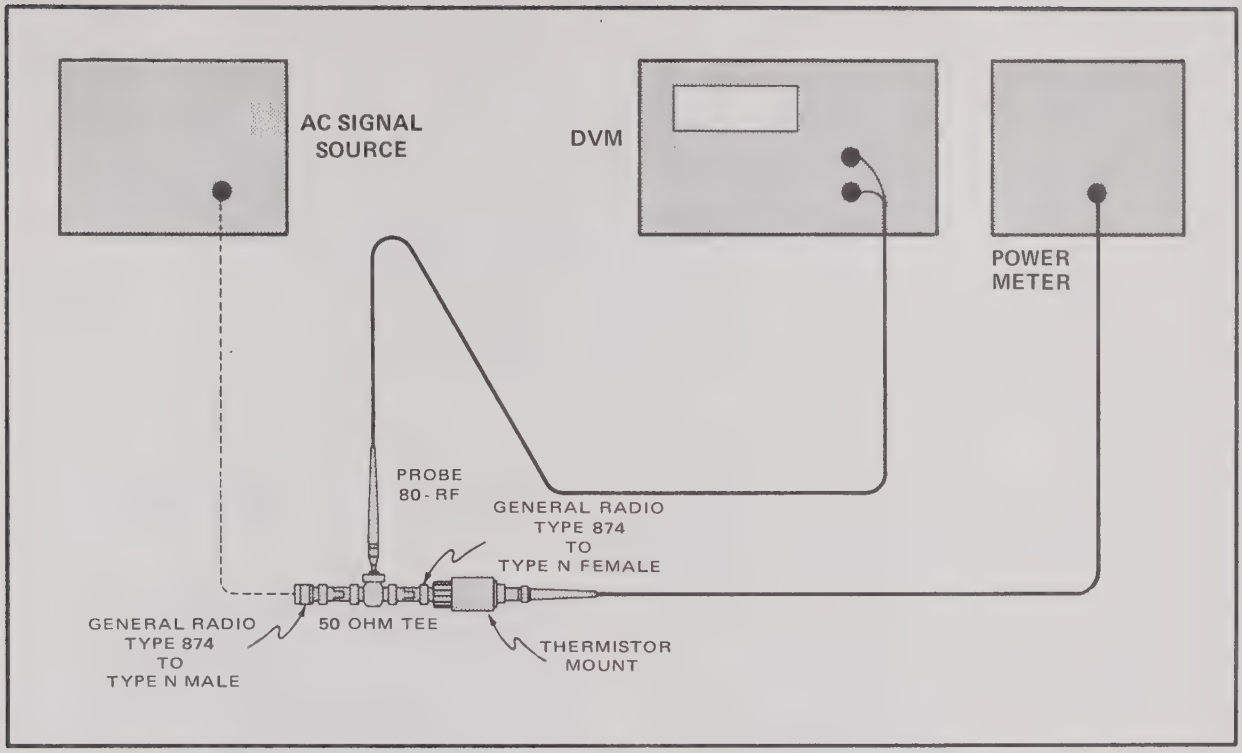



Figure 6-3. HIGH FREQUENCY RESPONSE CHECK

e. In connection "A", decrease the ac signal source an additional 10 db (to 0.3 volts) as indicated by the voltmeter in its ac function.

f. Back to "B", observe a voltmeter reading of .315 to .285 vdc.

g. Return the ac signal source back to 3.000 vrms.

h. Repeat steps a through g with frequencies of 500 kHz, 1 MHz, and 10 MHz.

6-17. HIGH FREQUENCY RESPONSE. Connect equipment to the 80-RF probe as shown in Figure 6-3, and perform the following steps:

a. Set the ac signal source ot 100 MHz with an output level of 10 milliwatts as indicated on the power meter. Ensure that the ac signal source has stabilized at 10 millivolts output.

b. Observe that the voltmeter indication is between 0.757 and 0.657 volts. (0.707 volts corresponds to 10 milliwatts in 50 ohms).

c. Repeat the above for frequencies of 200 MHz, 300 MHz, 400 MHz, and 480 MHz.

## 6-18. Calibration

6-19. Should the 80-RF require recalibration, perform the following steps:

a. Perform steps a and b in paragraph 6-16, with a frequency of 1 MHz.

b. Observe the dc voltmeter indication; a reading below 3 volts calls for a decrease in the value of R3, a reading above 3 volts calls for an increase in R3. Resistor R3 should be a 1/8 W metal film type. In a probe that is working properly, a 30 kΩ change in R3 will produce about a 1% reading deviation.

## 6-20. Cleaning

6-21. The Model 80-RF requires a minimum amount of cleaning. Accumulation of dust or dirt particles between the output terminals of the Model 80-RF can be removed using clean dry pressurized air. Stubborn particles can be removed following an application of isopropyl alcohol.

# ACCESSORY INFORMATION

## MODEL A90 CURRENT SHUNT

### 6-1. INTRODUCTION

6-2. The Model A90 Current Shunt is designed for use with any high-impedance ac or dc voltmeter capable of accurately measuring 100 millivolts. Six Fluke precision wire wound and strip resistors provide a 100 millivolt full-scale output for each of six pushbutton current ranges: 0.1, 1, 10, 100, and 1000 milliamperes and 10 amperes (ac or dc). Basic accuracy is specified over a frequency range of dc to 4 kHz for the 10 ampere range and dc to 10 kHz for the milliampere ranges.

6-3. The instrument is supplied in half-rack case so that it may be conveniently mounted side-by-side with other half-rack instruments in a standard 19-inch rack. A carrying handle detents into custom non-marring feet and serves as a tilt-up bail for bench use.

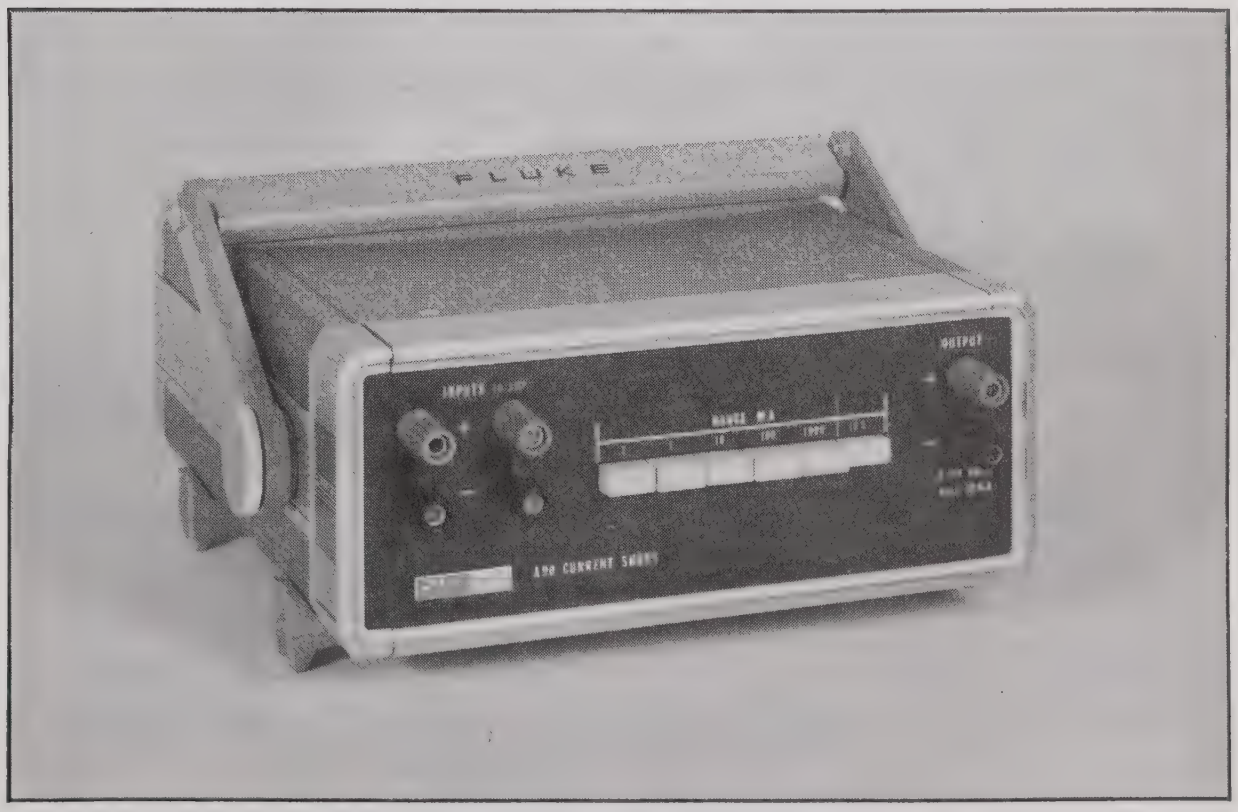
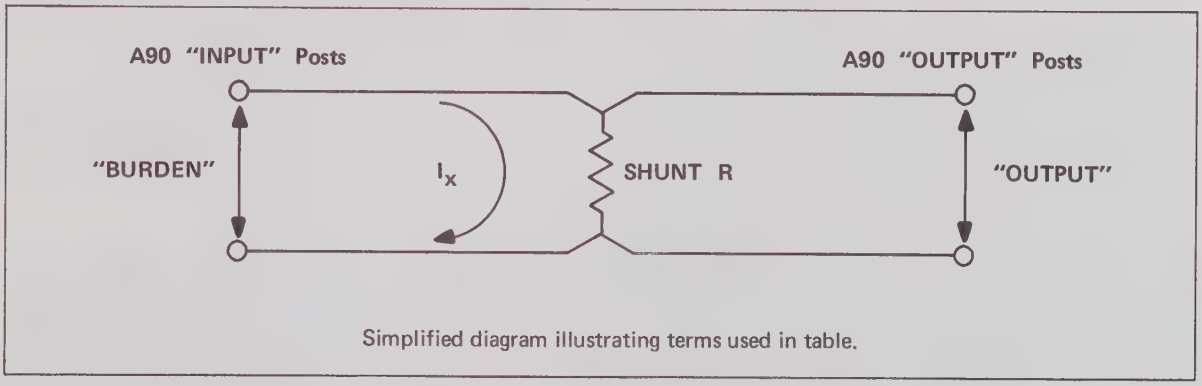



Figure 6-1. MODEL A90 CURRENT SHUNT

Table 6-1. ACCURACY OF A90 (1 year, 15°C - 35°C)

| RATED CURRENT RANGE | E BURDEN (APPROX.) | SHUNT R | "OUTPUT" AT RATED CURRENT | "OUTPUT" ACCURACY AS % OF CURRENT INPUT | |
|---|---|---|---|---|---|
| | | | | DC ONLY | DC TO 10 KHZ AC |
| 0.1 ma | 100 mv | 1 kΩ | 100 mv | ±0.1% | ±0.1% |
| * 0.1 ma | 100 mv | 1 kΩ | 100 mv | +0.0%<br>−0.2% | +0.0%<br>−0.2% |
| 1.0 ma | 100 mv | 100Ω | 100 mv | ±0.1% | ±0.1% |
| 10 ma | 100 mv | 10Ω | 100 mv | ±0.1% | ±0.1% |
| 100 ma | 102 mv | 1Ω | 100 mv | ±0.1% | ±0.1% |
| 1A | 120 mv | 0.1Ω | 100 mv | ±0.1% | ±0.2% |
| 10A | 300 mv | 0.01Ω | 100 mv | ±0.2% | ±0.3% (to 4 kHz) |

* With 1 MΩ Input R Voltmeter.
When Input R is ⩾10 MΩ, use non-asterisked 0.1 ma specification.




Simplified diagram illustrating terms used in table.

## 6-4. SPECIFICATIONS

## 6-5. Electrical

RANGE
0.1, 1, 10, 100, and 1000 milliamps and 10 amperes.

ACCURACY
Table 6-1 gives accuracy specifications for the Model A90 only. Total current measurement accuracy is also dependent on the accuracy and input impedance of the voltmeter being used.

SENSITIVITY
100 millivolts full scale.

OVERLOAD
Model A90 will not be damaged by 100% overload on each range below 10 amperes or by 50% overload on the 10 ampere range.

## 6-6. Mechanical

CURRENT SELECTION
Pushbutton, each range.

CONNECTORS
Positive (+) and negative (−) INPUT and OUTPUT binding posts with separate input posts for 10 ampere range.

DIMENSIONS
The Model A90 outline drawing is shown in Figure 6-2.

RACK MOUNTING KITS (OPTIONAL)
MEE-7014: Side-by-side Half-rack Mounting Kit
MEE-7006: Center Rack Mounting Kit
MEE-7013: Left or right of center Mounting Kit.

## 6-7. AUXILIARY ELECTRICAL SPECIFICATIONS

6-8. Tables 6-2 through 6-6 provide accuracy specifications for the Model A90 when used with Fluke Models

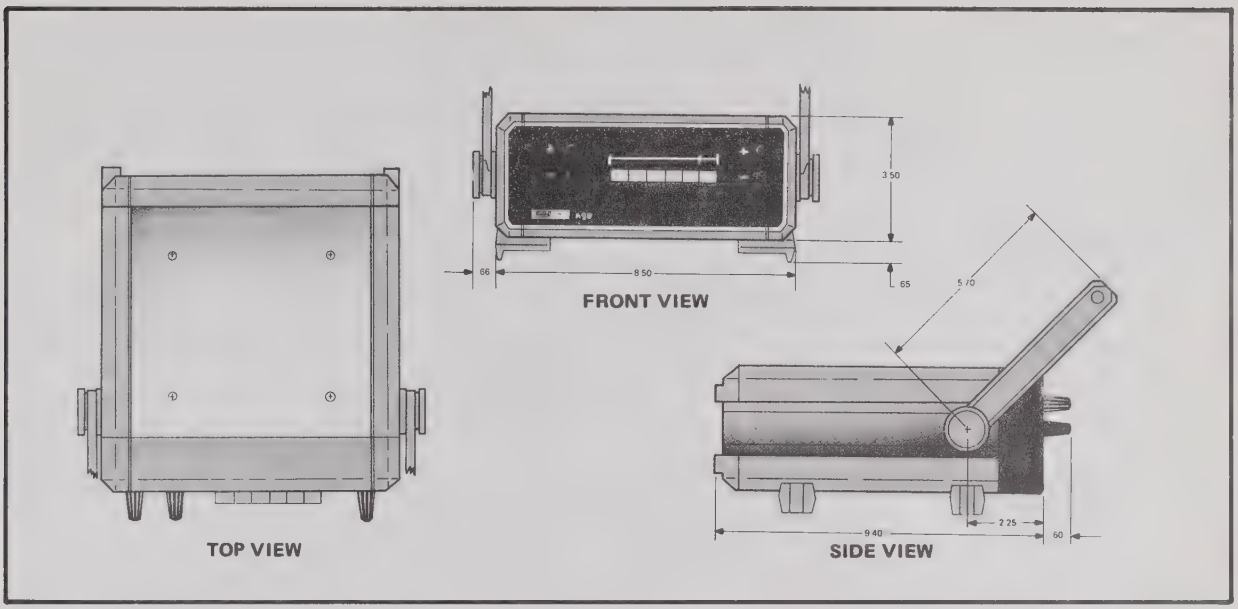



Figure 6-2. MODEL A90 OUTLINE DRAWING

Table 6-2. A90/8100A ACCURACY. 30 days, @ 23°C ±5°C.

| DC ACCURACY | |
|---|---|
| CURRENT RANGE | SPECIFICATION |
| 0.1 ma | ±(0.12% of current input + 0.1 ua) |
| 1.0 ma | ±(0.12% of current input + 1.0 ua) |
| 10 ma | ±(0.12% of current input + 10 ua) |
| 100 ma | ±(0.12% of current input + 0.1 ma) |
| 1A | ±(0.12% of current input + 1.0 ma) |
| 10A | ±(0.22% of current input + 10 ma) |

| AC ACCURACY | | |
|---|---|---|
| CURRENT RANGE | 30 Hz – 50 Hz | 50 Hz – 10 kHz |
| 0.1 ma | +(0.5% of current input + 1.0 ua)<br>–(0.7% of current input + 1.0 ua) | +(0.2% of current input + 0.5 ua)<br>–(0.4% of current input + 0.5 ua) |
| 1.0 ma | ±(0.6% of current input + 10 ua) | ±(0.3% of current input + 5.0 ua) |
| 10 ma | ±(0.6% of current input + 0.1 ma) | ±(0.3% of current input + 50 ua) |
| 100 ma | ±(0.6% of current input + 1.0 ma) | ±(0.3% of current input + 0.5 ma) |
| 1A | ±(0.7% of current input + 10 ma) | ±(0.4% of current input + 5.0 ma) |
| 10A | ±(0.8% of current input + 100 ma) | ±(0.5% of current input + 50 ma)* |

*10A specified to 4 kHz only.

| For: | DC CURRENT | AC CURRENT |
|---|---|---|
| | $V_r$ = 1v | $V_r$ = 1v |
| | $V_{dfs}$ = ±.1000 | $V_{dfs}$ = .1000 |

Table 6-3. A90/8300A ACCURACY

**DC CURRENT ACCURACY**

**MEASUREMENTS WITHOUT MV/OHMS OPTION INSTALLED**

| CURRENT RANGE | 24 hr @ 23°C ±1°C | 90 days @ 23°C ±5°C |
|---|---|---|
| 0.1 ma | ±(0.1% of current input + 0.1 ua) | ±(0.11% of current input + 0.3 ua) |
| 1.0 ma | ±(0.1% of current input + 1.0 ua) | ±(0.11% of current input + 3.0 ua) |
| 10 ma | ±(0.1% of current input + 10 ua) | ±(0.11% of current input + 30 ua) |
| 100 ma | ±(0.1% of current input + 0.1 ma) | ±(0.11% of current input + 0.3 ma) |
| 1A | ±(0.1% of current input + 1.0 ma) | ±(0.11% of current input + 3.0 ma) |
| 10A | ±(0.2% of current input + 10 ma) | ±(0.21% of current input + 30 ma) |

$V_r$ = 10 VDC

$V_{dfs}$ = 0.1000 (Readout also will display "DC +" or "DC –").

**MEASUREMENTS WITH MV/OHMS OPTION (8300A-02) INSTALLED**

| CURRENT RANGE | 90 days @ 23°C ±5°C |
|---|---|
| 0.1 ma | ±(0.11% of current input + 0.01 ua) |
| 1.0 ma | ±(0.11% of current input + 0.1 ua) |
| 10 ma | ±(0.11% of current input + 1.0 ua) |
| 100 ma | ±(0.11% of current input + 10 ua) |
| 1A | ±(0.11% of current input + 0.1 ma) |
| 10A | ±(0.21% of current input + 1.0 ma) |

$V_r$ = 100 MV (0.1v)

$V_{dfs}$ = 100.000 (Readout will also display MV DC + or MV DC–)

**AC CURRENT ACCURACY**

**MEASUREMENTS WITH AC OPTION 8300A-01 INSTALLED**

**90 days @ 23°C ±5°C using AC Zero control periodically.**

| CURRENT RANGE | 30 Hz – 50 Hz | 50 Hz – 10 kHz |
|---|---|---|
| 0.1 ma | +(0.5% of current input + 0.05 ua)<br>–(0.7% of current input + 0.05 ua) | +(0.1% of current input + 0.05 ua)<br>–(0.3% of current input + 0.05 ua) |
| 1.0 ma | ±(0.6% of current input + 0.5 ua) | ±(0.2% of current input + 0.5 ua) |
| 10 ma | ±(0.6% of current input + 5.0 ua) | ±(0.2% of current input + 5.0 ua) |
| 100 ma | ±(0.6% of current input + 50 ua) | ±(0.2% of current input + 50 ua) |
| 1A | ±(0.7% of current input + 0.5 ma) | ±(0.3% of current input + 0.5 ma) |
| 10A | ±(0.8% of current input + 5.0 ma) | ±(0.4% of current input + 5.0 ma)* |

$V_r$ = 1 VAC

$V_{dfs}$ = .10000 (Readout will also display "AC")

*10A specified to 4 kHz only.

Table 6-4. A90/9500A SPECIFICATIONS

**ACCURACY WHEN UNKNOWN CURRENT IS 20% OR MORE OF A90 CURRENT RANGE. (23°C ±1°C)**

| CURRENT RANGE | 20 Hz – 50 Hz | 50 Hz – 10 kHz |
|---|---|---|
| 0.1 ma | +(0.3% of current input + 0.02 ua)<br>–(0.5% of current input + 0.02 ua) | +(0.05% of current input + 0.015 ua)<br>–(0.25% of current input + 0.015 ua) |
| 1.0 ma | ±(0.4% of current input + 0.2 ua) | ±(0.15% of current input + 0.15 ua) |
| 10 ma | ±(0.4% of current input + 2.0 ua) | ±(0.15% of current input + 1.5 ua) |
| 100 ma | ±(0.4% of current input + 20 ua) | ±(0.15% of current input + 15 ua) |
| 1A | ±(0.5% of current input + 0.2 ma) | ±(0.25% of current input + 0.15 ma) |
| 10A | ±(0.6% of current input + 2.0 ma) | ±(0.35% of current input + 1.5 ma)* |

**ACCURACY WHEN UNKNOWN CURRENT IS BETWEEN 10% AND 20% OF A90 CURRENT RANGE.**

| A90 INPUT (% OF CURRENT RANGE) | % OF INPUT ABSOLUTE ACCURACY 20 Hz – 50 Hz @ 23°C ±1°C FOR A90 CURRENT RANGE | | | | |
|---|---|---|---|---|---|
| | 0.1 ma | | | | |
| | + | – | 1 ma – 100 ma | 1A | 10A |
| 10-11% | 0.53% | 0.73% | ± 0.63% | ±0.73% | ±0.83% |
| 12-14% | 0.50% | 0.70% | ± 0.60% | ±0.70% | ±0.80% |
| 15-17% | 0.47% | 0.67% | ± 0.57% | ±0.67% | ±0.77% |
| 18-20% | 0.44% | 0.64% | ± 0.54% | ±0.64% | ±0.74% |

| A90 INPUT (% OF CURRENT RANGE) | % OF INPUT ABSOLUTE ACCURACY 50 Hz – 10 kHz @23°C ±1°C FOR A90 CURRENT RANGE | | | | |
|---|---|---|---|---|---|
| | 0.1 ma | | | | |
| | + | – | 1 ma – 100 ma | 1A | 10A* |
| 10-11% | 0.23% | 0.43% | ±0.33% | ±0.43% | ±0.53% |
| 12-14% | 0.20% | 0.40% | ±0.30% | ±0.40% | ±0.50% |
| 15-17% | 0.17% | 0.37% | ±0.27% | ±0.37% | ±0.47% |
| 18-20% | 0.13% | 0.33% | ±0.23% | ±0.33% | ±0.43% |

$V_r$ = .1v

$V_{dfs}$ = .10000

TC = 0.005% of current input/°C 20 Hz –50 Hz
0.004% of current input/°C 50 Hz – 10 kHz

*10A is specified to 4 kHz only.

8100A, 8300A, 9500A, 891A, 893A, and 931B. Table 6-7 gives $V_r$ and $V_{dfs}$ for each of the voltmeters listed in the tables in addition to various other Fluke voltmeters, where

$V_r$ = Voltage range to be used on the voltmeter
and $V_{dfs}$ = Nominal voltmeter reading with full-scale current in A90 shunt.

## 6-9. INSTALLATION

6-10. There are three rack-mount kits available, at additional cost, for use with the Model A90. Kit MEE-7014 allows the Model A90 to be mounted side-by-side with another half-rack instrument in a standard 19-inch rack. Kit MEE-7006 supplies hardware necessary to mount the

Table 6-5. A90/891A AND 893A ACCURACY (Sheet 1 of 2)

| WITH 891A AND 893A – DC ACCURACY | | |
|---|---|---|
| CURRENT RANGE | @ 23°C ±2°C | @ 15°C –35°C |
| 0.1 ma | ±(0.11% of current input + 0.02 ua) | ±(0.12% of current input + 0.02 ua) |
| 1.0 ma | ±( 0.11% of current input + 0.2 ua) | ±(0.12% of current input + 0.2 ua) |
| 10 ma | ±( 0.11% of current input + 2.0 ua) | ±(0.12% of current input + 2.0 ua) |
| 100 ma | ±( 0.11% of current input + 20 ua) | ±(0.12% of current input + 20 ua) |
| 1A | ±( 0.11% of current input + 0.2 ma) | ±(0.12% of current input + 0.2 ma) |
| 10A | ±(0.21% of current input + 2.0 ma) | ±(0.22% of current input + 2.0 ma) |
| $V_r$ = 1v<br>$V_{dfs}$ = 0.10000 | | |

| WITH 893A – AC ACCURACY @ 23°C ±2°C | |
|---|---|
| CURRENT RANGE | 50 Hz – 10 kHz |
| 0.1 ma | +(0.05% of current input + 0.025 ua)<br>–(0.25% of current input + 0.025 ua) |
| 1.0 ma | ±(0.15% of current input + 0.25 ua) |
| 10 ma | ±(0.15% of current input + 2.5 ua) |
| 100 ma | ±(0.15% of current input + 25 ua) |
| 1A | ±(0.25% of current input + 0.25 ma) |
| 10A | ±(0.35% of current input + 2.5 ma)* |

| WITH 893A – AC ACCURACY @ 15°C –35°C | | |
|---|---|---|
| CURRENT RANGE | 5 Hz – 10 Hz | 10 Hz – 20 Hz |
| 0.1 ma | +(1.0% of current input + 0.25 ua)<br>–(1.2% of current input + 0.25 ua) | +(0.5% of current input + 0.1 ua)<br>–(0.7% of current input + 0.1 ua) |
| 1.0 ma | ±(1.1% of current input + 2.5 ua) | ±(0.6% of current input + 1.0 ua) |
| 10 ma | ±(1.1% of current input + 25 ua) | ±(0.6% of current input + 10 ua) |
| 100 ma | ±(1.1% of current input + 0.25 ua) | +(0.6% of current input + 0.1 ma) |
| 1A | ±(1.2% of current input + 2.5 ma) | ±(0.7% of current input + 1.0 ma) |
| 10A | ±(1.3% of current input + 25 ma) | ±(0.8% of current input + 10 ma) |

| 893A – AC ACCURACY @ 15°C –35°C. | | |
|---|---|---|
| CURRENT RANGE | 20 Hz – 50 Hz | 50 Hz – 10 kHz |
| 0.1 ma | +(0.15% of current input + 0.025 ua)<br>–(0.35% of current input + 0.025 ua) | +(0.1% of current input + 0.025 ua)<br>–(0.3% of current input + 0.025 ua) |
| 1.0 ma | ±(0.25% of current input + 0.25 ua) | ±(0.2% of current input + 0.25 ua) |
| 10 ma | ±(0.25% of current input + 2.5 ua) | ±(0.2% of current input + 2.5 ua) |
| 100 ma | ±(0.25% of current input + 25 ua) | ±(0.2% of current input + 25 ua) |
| 1A | ±(0.35% of current input + 0.25 ma) | ±(0.3% of current input + 0.25 ma) |
| 10A | ±(0.45% of current input + 2.5 ma) | ±(0.4% of current input + 2.5 ma)* |

Table 6-5. A90/891A AND 893A ACCURACY (Sheet 2 of 2)

| |
|---|
| $V_r$ = 1v (AC or DC)<br>$V_{dfs}$ = 0.10000<br>*10A is specified to 4 kHz only. |

Table 6-6. A90/931B SPECIFICATIONS

| ACCURACY WHEN UNKNOWN CURRENT IS 10% OR MORE OF A90 CURRENT RANGE | | | | |
|---|---|---|---|---|
| CURRENT RANGE | % OF INPUT ABSOLUTE ACCURACY 2 Hz – 3 Hz | 3 Hz – 5 Hz | 5 Hz – 30 Hz | SPECIFICATIONS 30 Hz – 10 kHz |
| 0.1 ma | +1.0%<br>–1.2% | +0.5%<br>–0.7% | +0.2%<br>–0.4% | +(0.05% of current input + 5 na)<br>–(0.25% of current input + 5 na) |
| 1.0 ma | ±1.1% | ±0.6% | ±0.3% | ±(0.15% of current input + 50 na) |
| 10 ma | ±1.1% | ±0.6% | ±0.3% | ±(0.15% of current input + 0.5 ua) |
| 100 ma | ±1.1% | ±0.6% | ±0.3% | ±(0.15% of current input + 5 ua) |
| 1A | ±1.2% | ±0.7% | ±0.4% | ±(0.25% of current input + 50 ua) |
| 10A | ±1.3% | ±0.8% | ±0.5% | ±(0.35% of current input + 0.5 ma)* |
| TC= | ±0.1%/°C | ±0.05%/°C | ±0.025%/°C | ±0.0025%/°C |

$V_r$ = 100 MV
$V_{dfs}$ = 100.000

*10A is specified to 4 kHz only.

Table 6-7. "$V_r$" AND "$V_{dfs}$" FOR VOLTMETERS OF TABLES 6-2 THROUGH 6-6

| VOLTMETER | "$V_r$" | "$V_{dfs}$" |
|---|---|---|
| 8300A (Without MV/Ohms) | 10v | .010 |
| 8100A, 871A, 873A, 881A, 883A, 885A, 887A, 891A, 893A | 1v | .100 |
| 801, 803, 801B, 803B, 803D, 821A, 823A, 825A | 0.5v | .100 |
| 9500A, 910A | 0.1v | .100 |
| 8300A (With MV/Ohms), 931A, 931B | 100 MV | 100.0 |

$V_r$ = Voltage range to be used on the voltmeter.
$V_{dfs}$ = Nominal voltmeter reading with full-scale current in A90 shunt.

instrument in the center of the rack. Kit MEE-7013 supplies two different sized rack ears so that the instrument can be mounted to the left or to the right of rack center.

## 6-11. OPERATING INSTRUCTIONS

6-12. A description of Model A90 controls and terminals is given in Figure 6-3.

## 6-13. Equipment Connections

6-14. It is recommended that the Model A90 always be used in the "LO" lead as shown in Figure 6-4A. When used in the "HI" lead, as shown in Figure 6-4B, the distributed capacitance, $C_{DIST}$, loads the source. When connected in the "HI" lead, the voltmeter guard should either be connected as shown or else the voltmeter should be battery operated.

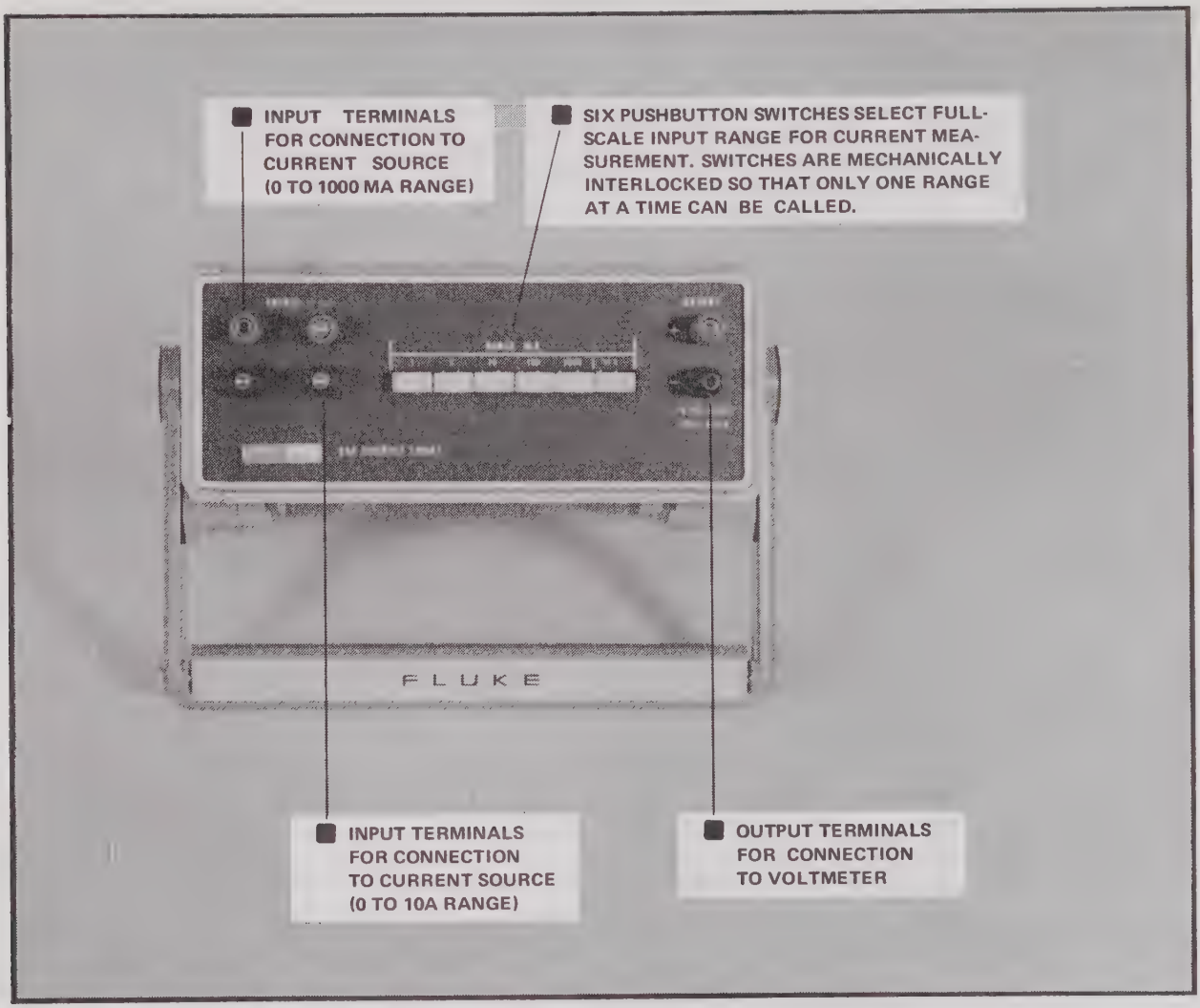

INPUT TERMINALS FOR CONNECTION TO CURRENT SOURCE (0 TO 1000 MA RANGE)
SIX PUSHBUTTON SWITCHES SELECT FULL-SCALE INPUT RANGE FOR CURRENT MEASUREMENT. SWITCHES ARE MECHANICALLY INTERLOCKED SO THAT ONLY ONE RANGE AT A TIME CAN BE CALLED.
FLUKE
INPUT TERMINALS FOR CONNECTION TO CURRENT SOURCE (0 TO 10A RANGE)
OUTPUT TERMINALS FOR CONNECTION TO VOLTMETER

Figure 6-3. MODEL A90 CONTROLS AND TERMINALS.

6-15. At high ac currents, performance of the A90 may depend upon the manner in which the current leads are connected to the input binding posts. Optimum performance is obtained when the input current leads are twisted.

## 6-16. Voltmeter Impedance

6-17. The input impedance of the voltmeter which is used with the Model A90 is significant with regard to total measurement accuracy. As indicated in the specifications, Model A90 measurement accuracy is derated for voltmeters having finite input impedance. As the voltmeter input capacity increases, the Model A90 response rolls off at the high end; and as the voltmeter input resistance decreases, the response shifts downward, resulting in negative measurement errors.

## 6-18. Combining Model A90 And Voltmeter Specifications

6-19. Combined specifications for the A90 when used with various Fluke voltmeters is given in Tables 6-2 through 6-6. When the A90 is used with other voltmeters, the following information may be used to combine specifications.

6-20. Equation 1 (Figure 6-5) is used to combine A90 and voltmeter specifications for overall accuracy. The "W" term is taken from Table 6-1, and the "X", "Y" and "Z" terms are taken from voltmeter specifications (data sheets). All Fluke voltmeter specifications, except the Model 910A, contain the "X" term; they usually list the "Y" term and occasionally the "Z" term. Model 910A accuracy specifi-

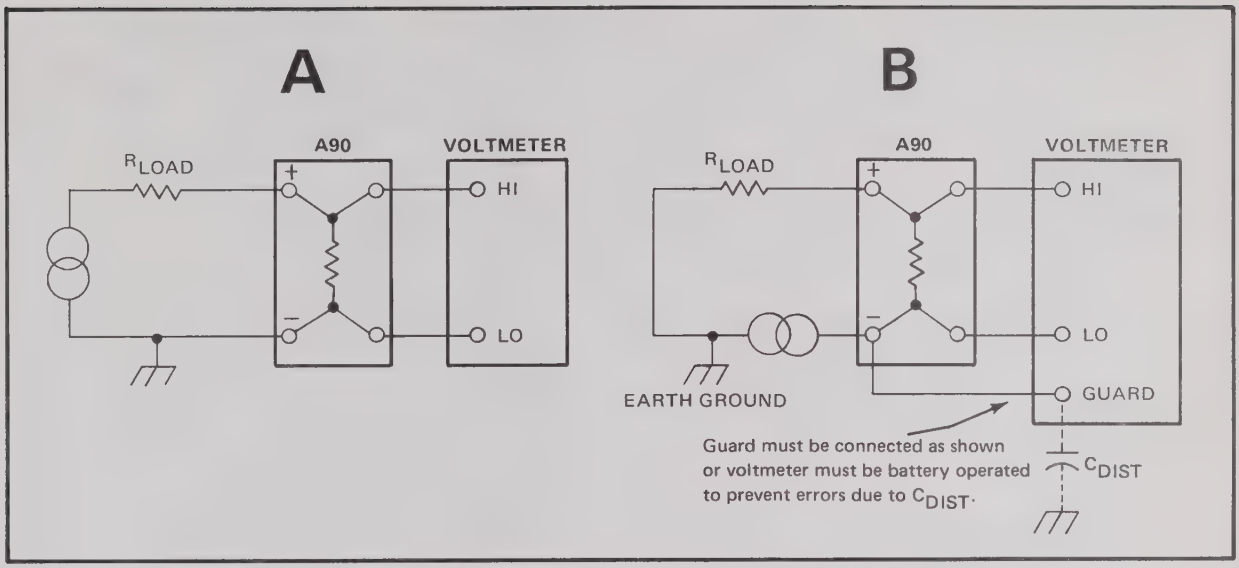



Figure 6-4. EQUIPMENT CONNECTIONS FOR CURRENT MEASUREMENT.

**EQUATION 1. COMBINING A-90 SPECIFICATION WITH VOLTMETER SPECIFICATION.**

A-90 Specification (from Table 6-1) — Voltmeter Specification (from Voltmeter Data Sheet)

$$\pm\ |\ W\ |\ \%\qquad \pm\ (\ |\ X\ |\ \%\ \text{of input} + |\ Y\ |\ \%\ \text{of range} + |\ Z\ |\ \text{uv}\ )$$

Vr = Lowest voltmeter range that will measure 100 MV

$$= +\left[\ (\ W + X\ )\ \%\ \text{of current input} + \frac{Vr}{0.1} \times \left(\ Y + \frac{Z}{10000}\ \right)\ \%\ \text{of current range}\right]$$

EXAMPLE 1: Accuracy using 10 ma DC A-90 range with 891A.

A-90 Specification (from Table 6-1) — 891A Specification (from 891A Data Sheet)

$$\pm\ |\ 0.1\ |\ \%\qquad \pm\ (\ |\ 0.01\ |\ \%\ \text{of input} + |\ 0.001\ |\ \%\ \text{of range} + |\ 10\ |\ \text{uv}\ )$$

Vr = 1.0 (891A's 1v DC Range)

$$= \pm\left[\ (0.1 + 0.01\ )\ \%\ \text{of current input} + \frac{1.0}{0.1} \times \left(\ 0.001 + \frac{10}{10{,}000}\ \right)\ \%\ \text{of current range}\right]$$

$$= \pm\left[\ 0.11\%\ \text{of current input} + 0.02\%\ \text{of current range}\ \right]$$

$$= \pm\left[\ 0.11\%\ \text{of current input} + 2\ \text{ua}\ \right]$$

Figure 6-5. EQUATION 1 – COMBINING A90 AND VOLTMETER SPECIFICATIONS (Sheet 1 of 2)

EXAMPLE 2: Accuracy using 0.1 ma AC A-90 range with 873A at 1 kHz.

Model 873A has 1 megohm input impedance in its AC mode so separate accuracy statements are required for positive and negative limits of error for measurements made on the A-90's 0.1 ma range.

Positive Limit of Error

A-90 Specification: + | 0.0 | %

873A Specification: ± | 0.2 | % of input + | 25 | uv

"Vr" is 873A's 1v AC Range

No "Y" Term In Spec.

$$= +\left[(0.0 + 0.2)\ \%\ \text{of current input} + \frac{1}{0.1} \times \left(0 + \frac{25}{10000}\right)\ \%\ \text{of current range}\right]$$

$$= +\left[\ 0.2\%\ \text{of current input} + 0.025\%\ \text{of current range}\ \right]$$

Negative Limit of Error

$$= -\left[\ (0.2 + 0.2)\ \%\ \text{of current input} + 0.025\%\ \text{of current range}\ \right]$$

$$= -\left[\ 0.4\%\ \text{of current input} + 0.025\%\ \text{of current range.}\ \right]$$

Figure 6-5. EQUATION 1 – COMBINING A90 AND VOLTMETER SPECIFICATIONS (Sheet 2 of 2)

cation consists of "Y" term only. If "X", "Y", or "Z" do not appear in a voltmeter accuracy specification, it should be treated as a zero in Equation 1. The voltmeter must be used on the lowest range that can measure 100 millivolts. This range is assigned the symbol "$V_r$" in Equation 1. $V_r$ is always stated as volts, i.e., 100 millivolt range equals 0.1 volts for $V_r$ .

6-21. Equation 2 (Figure 6-6) may be used to convert the voltmeter voltage reading to current.

## 6-22. THEORY OF OPERATION

6-23. The schematic diagram of the Model A90 is located at the back of the manual. In the milliampere ranges, current is directed through the appropriate shunt resistor by switches S1A through S5A, and the corresponding output voltage is connected to the output terminals through switches S1 through S5, decks B and C. In 10 ampere range, the input current is applied directly to the shunt resistor, and the output voltage is connected to the output terminals through switch S6.

6-24. All shunt resistors are four-terminal shunts or are connected in a four-terminal switching arrangement so that lead resistance does not affect measurement accuracy.

## 6-25. MAINTENANCE

6-26. The following paragraphs contain instructions for cleaning and calibrating the Model A90.

### 6-27. Cleaning

6-28. The instrument should be cleaned periodically to remove dust, grease, and other contamination. The following procedure should be adhered to when cleaning the instrument:

a. Remove loose contamination with low-pressure, clean, dry air.

b. Clean front panel and exterior surfaces with anhydrous ethyl alcohol or a soft cloth dampened in a mild solution of detergent and water.

CAUTION!

**Do not use aromatic hydrocarbons or chlorinated solvents on the front panel, because they will react with the Lexan binding posts.**

$$I_x = I_r \times \frac{V_d}{V_{dfs}}$$

Where: $I_x$ = magnitude of unknown current in units of A90 "RANGE" used. (i.e. ma or amps).

$I_r$ = A90 Rated Current "RANGE".

$V_d$ = Voltmeter reading.

$V_{dfs}$ = Nominal Voltmeter reading with rated current flowing in A90. "$V_{dfs}$" and "$V_r$" are tabulated in Table 6-7 for each voltmeter listed in Tables 6-2 through 6-6. Note that "$V_{dfs}$" multiplies or divides "$V_d$" by powers of 10 so it is simple to manipulate.

EQUATION 2. CONVERTING VOLTAGE READINGS TO CURRENT

Example: An 8100A reads =.0643 when used with an A90 in the 10 ma range. What current is flowing?

$I_r$ = 10 ma (A90 "Rated Current Range")

$V_d$ = .0643 (Voltmeter reading)

$V_{dfs}$ = .1000 (From Table 6-7)

Answer: $I_x = 10 \text{ ma} \times \frac{.0643}{.1000} = 6.43 \text{ ma}$

Figure 6-6. Equation 2 – CONVERTING VOLTAGE READINGS TO CURRENT

## 6-29. Test Equipment

6-30. Test equipment required for calibration and testing of the Model A90 is shown in Table 6-8. If the recommended equipment is not available, other equivalent equipment may be used.

Table 6-8. LIST OF TEST EQUIPMENT

| NAME | RECOMMENDED EQUIPMENT |
|---|---|
| Constant Current Source | Fluke Model 382A |
| DC Differential Voltmeter | Fluke Model 895A or 885A |
| Low-Thermal Leads | |
| 4-Terminal Ohmmeter | Fluke Model 8300A with Option -02 |

## 6-31. Calibration

6-32. PRELIMINARY CHECKS. Make the resistance checks shown in Table 6-9. Values are approximate since check is intended to show only gross errors, such as defective or open resistors.

6-33. .1 MA AND 1 MA RANGE CHECKS. Connect the ohmmeter and A90, as shown in Figure 6-7, for 4-terminal resistance measurements, and perform the following steps:

a. Set the A90 to the .1 MA range. The ohmmeter should indicate between 1.00050 and 0.99950 kilohms. If the measured resistance is not within these limits, the .1 MA shunt, R6, is defective and must be replaced.

b. Set the A90 to the 1 MA range. The ohmmeter should indicate between 100.07 and 99.93 ohms. If the measured resistance is not within these limits, the 1 MA shunt, R5, is defective and must be replaced.

6-34. 10 MA, 100 MA, AND 1000 MA RANGE CHECKS. Connect the constant current generator, differential voltmeter, and A90 as shown in Figure 6-8 and perform the following steps:

a. Set the A90 to the 10 MA range.

b. Set the differential voltmeter controls as follows:

| | |
|---|---|
| RANGE | 1 Volt |
| NULL Sensitivity | 100 $\mu$V |
| Readout Dials | 0.100000 |

Table 6-9. RESISTANCE CHECKS

| OHMMETER CONNECTIONS | MODEL A90 | |
|---|---|---|
| | RANGE | APPROXIMATE RESISTANCE (OHMS) |
| INPUT Terminals | .1 MA | 1000 |
| | 1 MA | 100 |
| | 10 MA | 10 |
| | 100 MA | 1 |
| | 1000 MA | 0.1 |
| | 10A | ∞ |
| INPUT (10A Terminals) | 10A | 0.01 |
| OUTPUT Terminals | 10A | 0.01 |
| | 1000 MA | 0.1 |
| | 100 MA | 1 |
| | 10 MA | 10 |
| | 1 MA | 100 |
| | .1 MA | 1000 |

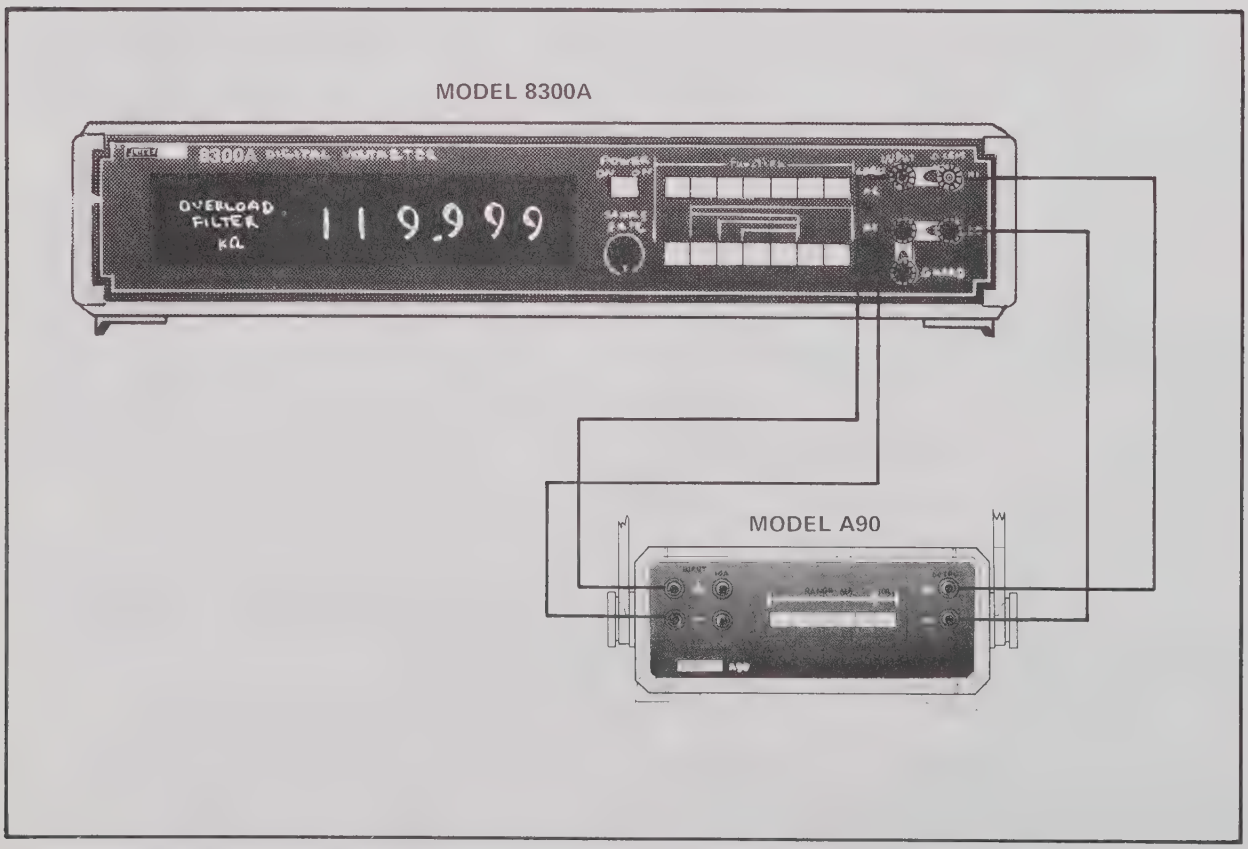



Figure 6-7. EQUIPMENT CONNECTIONS – .1 MA AND 1 MA RANGE CHECKS

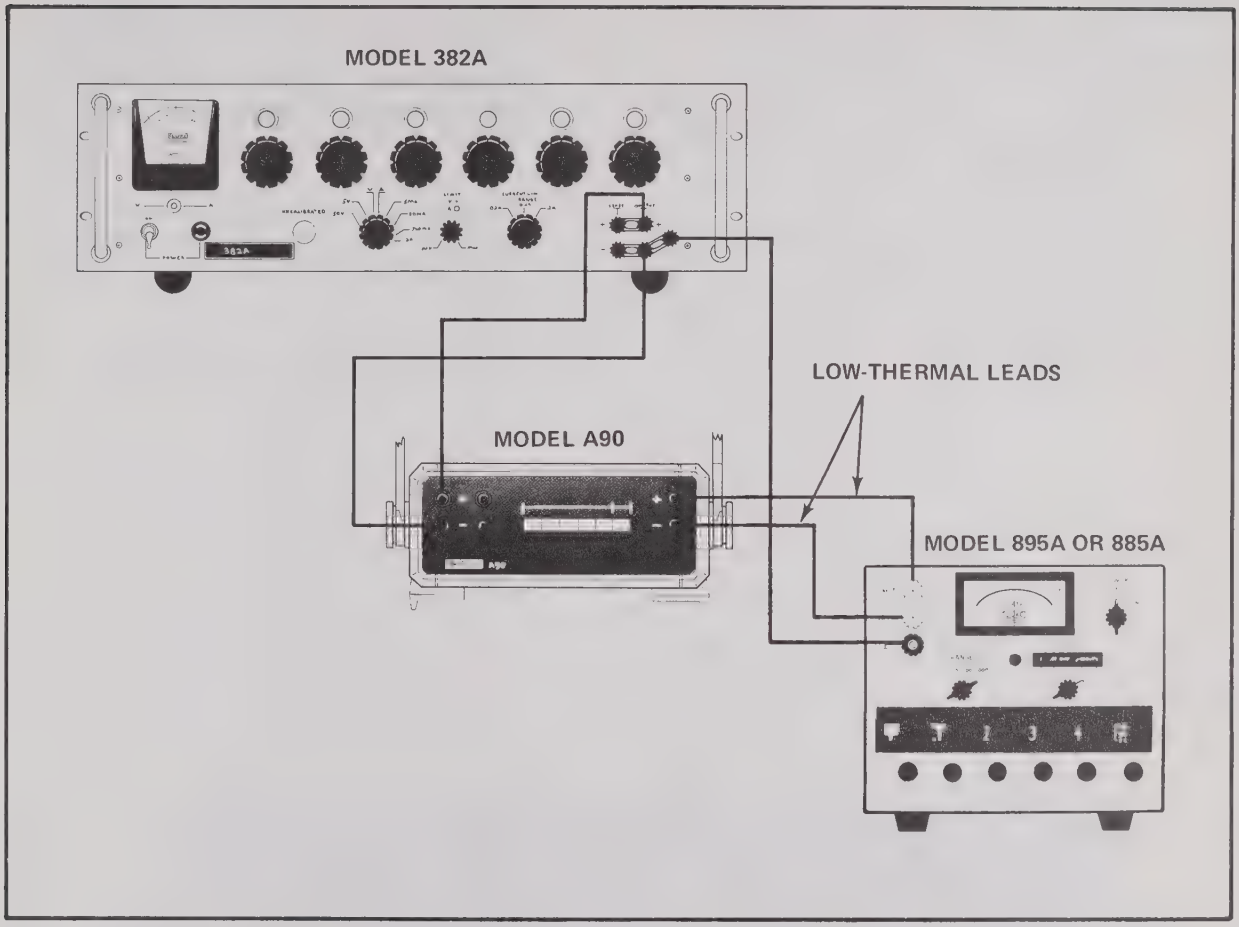



Figure 6-8. EQUIPMENT CONNECTIONS – 10 MA, 100 MA, AND 1000 MA RANGE CHECKS

c. Set the constant current generator for 10.0000 milliamperes output. The differential voltmeter should indicate null within ±80 micorvolts. If the voltmeter does not indicate within these limits, the 10 MA shunt, R4, is defective and must be replaced.

d. Change the A90 range to 100 MA and the constant current generator output to 100 milliamperes. The differential voltmeter should indicate null within ±80 microvolts. If the voltmeter does not indicate within these limits, the 100 MA shunt, R3, is defective and must be replaced.

e. Change the A90 range to 1000 MA and the constant current generator output to 1000 milliamperes. The differential voltmeter should indicate null within ±80 microvolts. If the +80 microvolt limit is not met, the 1000 MA shunt, R2, should be replaced. If the –80 microvolt limit is not met, R2 is low in ohmic value and can be trimmed to its desired value by carefully removing a small amount of material from the edge of the shunt using a whetstone.

6-35. 10 AMPERE RANGE CHECK. Connect equipment as shown in Figure 6-8, leaving the constant current generator temporarily disconnected from the A90, and perform the following steps:

a. Set the differnetial voltmeter controls as follows:

| | |
|---|---|
| RANGE | 1 Volt |
| NULL Sensitivity | 100 $\mu$V |
| Readout Dials | 0.00000 |

The voltmeter should indicate less than ±4 microvolts of thermal offset. If more than ±4 microvolts of offset is observed, check for cold solder joints or possible thermal generators in the test

setup. When thermal offset has been reduced to within ±4 microvolts, proceed to step (b).

b. Connect the constant current generator to the 10 AMP binding posts of the A90 and set the A90 to the 10A range.

c. Set the differential voltmeter controls as follows:

| | |
|---|---|
| RANGE | 1 Volt |
| NULL Sensitivity | 100 μV |
| Readout Dials | .020000 |

d. Set the constant current generator output to 2 amperes. The voltmeter should indicate null within ±80 microvolts. If the +80 microvolt limit is not met, the 10 ampere shunt, R1, should be replaced. If the –80 microvolt limit is not met, R1 is low in ohmic value and can be trimmed to its desired value by carefully removing a small amount of material from the edge of the shunt using a whetstone.

## 6-36. LIST OF REPLACEABLE PARTS

| REF DESIG | INDEX NO | DESCRIPTION | STOCK NO | MFR | MFR PART NO | TOT QTY | REC QTY | USE CODE |
|---|---|---|---|---|---|---|---|---|
| | | **CURRENT SHUNT — Figure 6-9** | A90 | | | | | |
| | | Shunt PCB Assembly (See Figure 6-9) | A90-403 | 89536 | A90-403 | 1 | | |
| J1, J2, J5 | | Binding post, red, + | 275552 | 89536 | 275552 | 3 | | |
| J3, J4, J6 | | Binding post, black – | 275560 | 89536 | 275560 | 3 | | |
| | | Cover, bottom | 224360 | 89536 | 224360 | 1 | | |
| | | Cover, top | 224352 | 89536 | 224352 | 1 | | |
| | | Foot | 230037 | 89536 | 230337 | 4 | | |
| | | Handle, carrying | 231423 | 89536 | 231423 | 1 | | |
| | | Panel, front | A90-208 | 89536 | A90-208 | 1 | | |
| | | Panel, rear | A90-209 | 89536 | A90-209 | 1 | | |

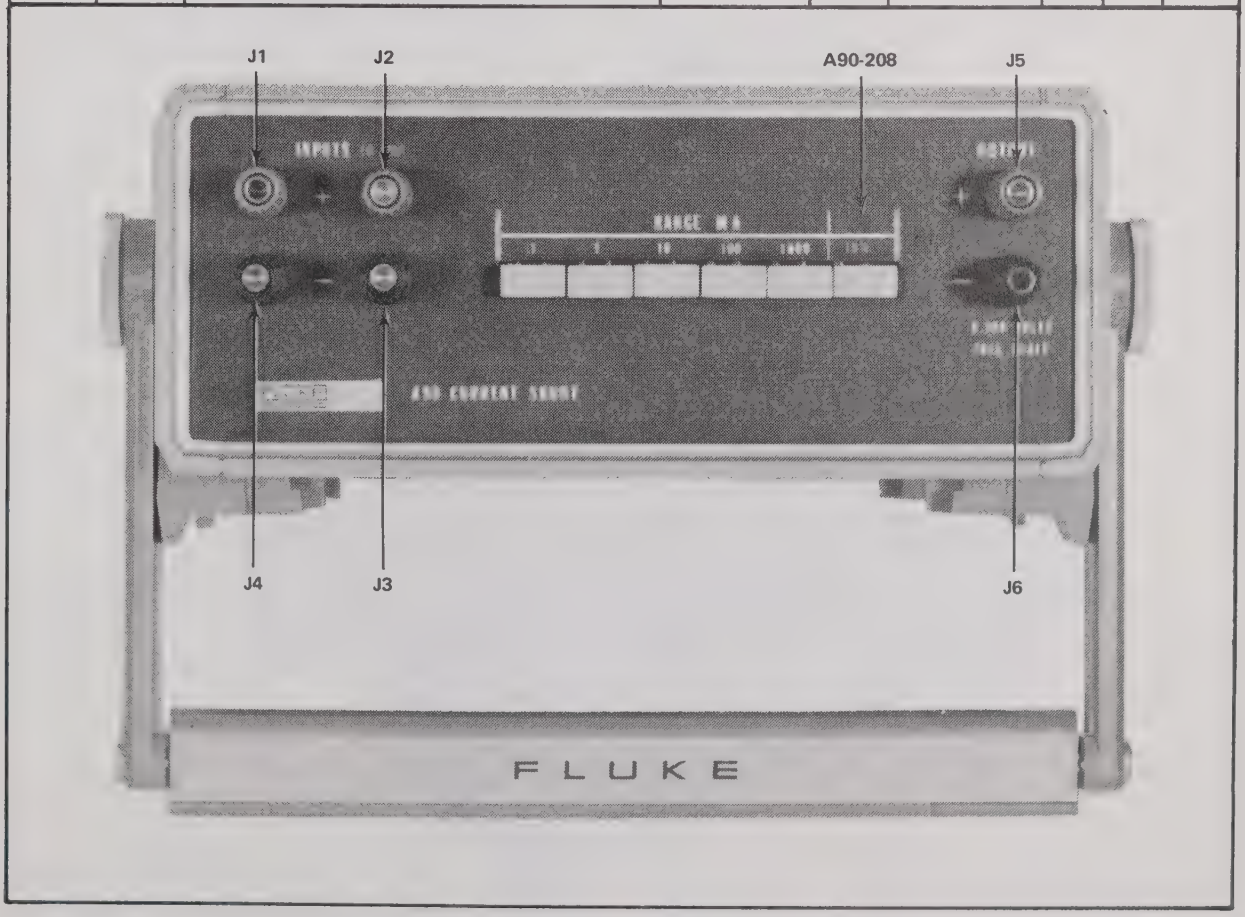



Figure 6-9. MODEL A90 CURRENT SHUNT (Sheet 1 of 2)

| REF DESIG | INDEX NO | DESCRIPTION | STOCK NO | MFR | MFR PART NO | TOT QTY | REC QTY | USE CODE |
|---|---|---|---|---|---|---|---|---|
| | | **SHUNT PCB ASSEMBLY — Figure 6-9** | A90-403 | 89536 | A90-403 | REF | | |
| R1 | | Res, ww, 0.010Ω ±0.2%, 1w | 34-4022 | 89536 | 34-4022 | 1 | | |
| R2 | | Res, ww, 0.10Ω ±0.1%, 1w | 224121 | 89536 | 224121 | 1 | | |
| R3 | | Res, ww, 1.0Ω ±0.1%, ½w | 224089 | 89536 | 224089 | 1 | | |
| R4 | | Res, ww, 10Ω ±0.1%, ½w | 224071 | 89536 | 224071 | 1 | | |
| R5 | | Res, ww, 100Ω ±0.03%, ½w | 155846 | 89536 | 155846 | 1 | | |
| R6 | | Res, ww, 1 KΩ ±0.04%, ½w | 131706 | 89536 | 131706 | 1 | | |
| S1 thru S6 | | Switch assembly,RANGE MA | A90-802 | 89536 | A90-802 | 1 | | |

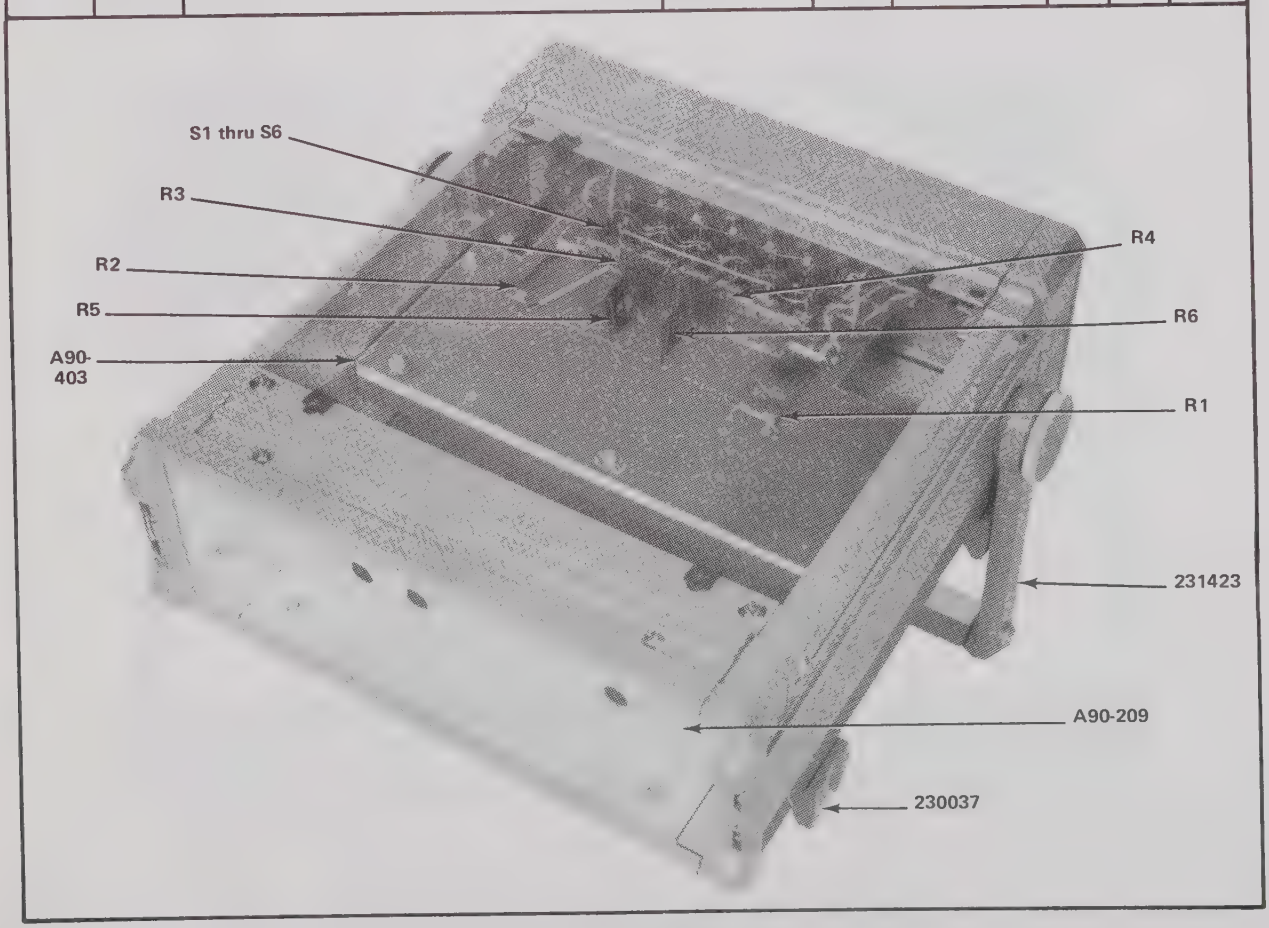
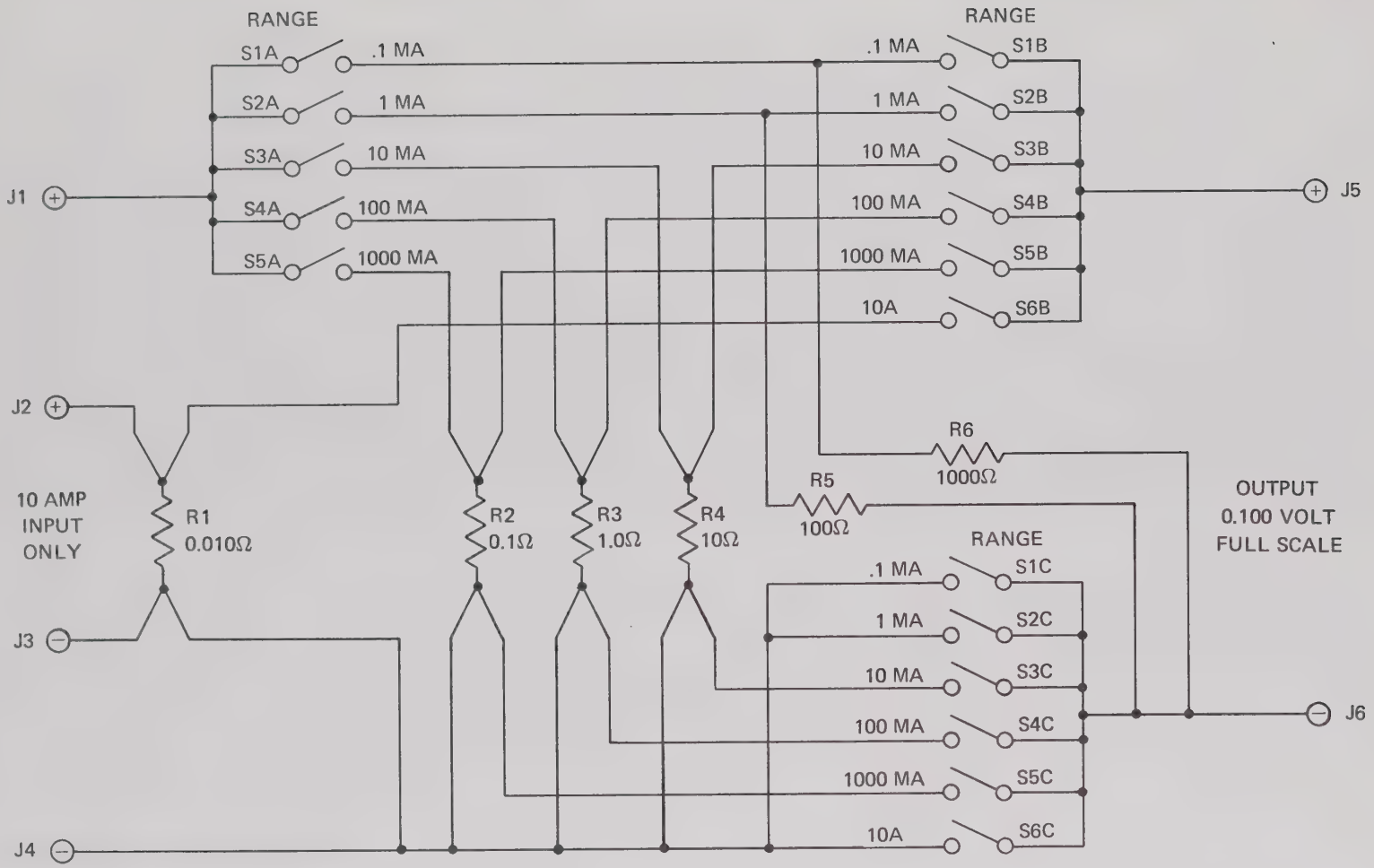



Figure 6-9. MODEL A90 CURRENT SHUNT (Sheet 2 of 2)




| FUNCTIONAL SCHEMATIC DIAGRAM | |
|---|---|
| MODEL A90<br>CURRENT SHUNT | |
| SER. NO. 123 & ON | REV<br>a |
| FLUKE JOHN FLUKE MFG. CO., INC.<br>P.O. Box 7428 Seattle, Washington 98133 | |

## Section 7

# General Information

7-1. This section of the manual contains generalized user information as well as supplemental information to the List of Replaceable Parts contained in Section 5.

## List of Abbreviations and Symbols

| | |
|---|---|
| **A or amp** | ampere |
| **ac** | alternating current |
| **af** | audio frequency |
| **a/d** | analog-to-digital |
| **assy** | assembly |
| **AWG** | american wire gauge |
| **B** | bel |
| **bcd** | binary coded decimal |
| **°C** | Celsius |
| **cap** | capacitor |
| **ccw** | counterclockwise |
| **cer** | ceramic |
| **cermet** | ceramic to metal(seal) |
| **ckt** | circuit |
| **cm** | centimeter |
| **cmrr** | common mode rejection ratio |
| **comp** | composition |
| **cont** | continue |
| **crt** | cathode-ray tube |
| **cw** | clockwise |
| **d/a** | digital-to-analog |
| **dac** | digital-to-analog converter |
| **dB** | decibel |
| **dc** | direct current |
| **dmm** | digital multimeter |
| **dvm** | digital voltmeter |
| **elect** | electrolytic |
| **ext** | external |
| **F** | farad |
| **°F** | Fahrenheit |
| **FET** | Field-effect transistor |
| **ff** | flip-flop |
| **freq** | frequency |
| **FSN** | federal stock number |
| **g** | gram |
| **G** | giga ($10^9$) |
| **gd** | guard |
| **Ge** | germanium |
| **GHz** | gigahertz |
| **gmv** | guaranteed minimum value |
| **gnd** | ground |
| **H** | henry |
| **hd** | heavy duty |
| **hf** | high frequency |
| **Hz** | hertz |
| **IC** | integrated circuit |
| **if** | intermediate frequency |
| **in** | inch(es) |
| **intl** | internal |
| **I/O** | input/output |
| **k** | kilo ($10^3$) |
| **kHz** | kilohertz |
| **kΩ** | kilohm(s) |
| **kV** | kilovolt(s) |
| **lf** | low frequency |
| **LED** | light-emitting diode |
| **LSB** | least significant bit |
| **LSD** | least significant digit |
| **M** | mega ($10^6$) |
| **m** | milli ($10^{-3}$) |
| **mA** | milliampere(s) |
| **max** | maximum |
| **mf** | metal film |
| **MHz** | megahertz |
| **min** | minimum |
| **mm** | millimeter |
| **ms** | millisecond |
| **MSB** | most significant bit |
| **MSD** | most significant digit |
| **MTBF** | mean time between failures |
| **MTTR** | mean time to repair |
| **mV** | millivolt(s) |
| **mv** | multivibrator |
| **MΩ** | megohm(s) |
| **n** | nano ($10^{-9}$) |
| **na** | not applicable |
| **NC** | normally closed |
| **(-) or neg** | negative |
| **NO** | normally open |
| **ns** | nanosecond |
| **opnl ampl** | operational amplifier |
| **p** | pico ($10^{-12}$) |
| **para** | paragraph |
| **pcb** | printed circuit board |
| **pF** | picofarad |
| **pn** | part number |
| **(+) or pos** | positive |
| **pot** | potentiometer |
| **p-p** | peak-to-peak |
| **ppm** | parts per million |
| **PROM** | programmablle read-only memory |
| **psi** | pound-force per square inch |
| **RAM** | random-access memory |
| **rf** | radio frequency |
| **rms** | root mean square |
| **ROM** | read-only memory |
| **s or sec** | second (time) |
| **scope** | oscilloscope |
| **SH** | shield |
| **Si** | silicon |
| **serno** | serial number |
| **sr** | shift register |
| **Ta** | tantalum |
| **tb** | terminal board |
| **tc** | temperature coefficient or temperature compensating |
| **tcxo** | temperature compensated crystal oscillator |
| **tp** | test point |
| **u or μ** | micro ($10^{-6}$) |
| **uhf** | ultra high frequency |
| **us or μs** | microsecond(s) ($10^{-6}$) |
| **uut** | unit under test |
| **V** | volt |
| **v** | voltage |
| **var** | variable |
| **vco** | voltage controlled oscillator |
| **vhf** | very high frequency |
| **vlf** | very low frequency |
| **W** | watt(s) |
| **ww** | wire wound |
| **xfmr** | transformer |
| **xstr** | transistor |
| **xtal** | crystal |
| **xtlo** | crystal oscillator |
| **Ω** | ohm(s) |
| **μ** | micro ($10^{-6}$) |

## Federal Supply Codes for Manufacturers

00213
Nytronics Comp. Group Inc.
Subsidiary of Nytronics Inc.
Formerly Sage Electronics
Rochester, New York

00327
Welwyn International, Inc.
Westlake, Ohio

00656
Aerovox Corp.
New Bedford, Massachusetts

00686
Film Capacitors, Inc.
Passaic, New Jersey

00779
AMP Inc.
Harrisburg, Pennsylvania

01121
Allen-Bradley Co.
Milwaukee, Wisconsin

01281
TRW Electronic Comp.
Semiconductor Operations
Lawndale, California

01295
Texas Instruments, Inc.
Semiconductor Group
Dallas, Texas

01537
Motorola Communications &
Electronics Inc.
Franklin Park, Illinois

01686
RCL Electronics Inc.
Manchester, New Hampshire

01730
Replaced by 73586

01884
Use 56289
Sprague Electric Co.
Dearborn Electronic Div.
Lockwood, Florida

02114
Ferroxcube Corp.
Saugerties, New York

02131
General Instrument Corp.
Harris ASW Div.
Westwood, Maine

02395
Rason Mfg. Co.
Brooklyn, New York

02533
Snelgrove, C.R. Co., Ltd.
Don Mills, Ontario, Canada
M3B 1M2

02606
Fenwal Labs
Div. of Travenal Labs.
Morton Grove, Illinois

02660
Bunker Ramo Corp., Conn Div.
Formerly Amphenol-Borg
Electric Corp.
Broadview, Illinois

02799
Areo Capacitors, Inc.
Chatsworth, California

03508
General Electric Co.
Semiconductor Products
Syracuse, New York

03614
Replaced by 71400

03651
Replaced by 44655

03797
Eldema Div.
Genisco Technology Corp.
Compton, California

03877
Transistron Electronic Corp.
Wakefield, Massachusetts

03888
KDI Pyrofilm Corp.
Whippany, New Jersey

03911
Clairex Electronics Div.
Clairex Corp.
Mt. Vernon, New York

03980
Muirhead Inc.
Mountainside, New Jersey

04009
Arrow Hart Inc.
Hartford, Connecticut

04062
Replaced by 72136

04202
Replaced by 81312

04217
Essex International Inc.
Wire & Cable Div.
Anaheim, California

04221
Aemco, Div. of
Midtex Inc.
Mankato, Minnesota

04222
AVX Ceramics Div.
AVX Corp.
Myrtle Beach, Florida

04423
Telonic Industries
Laguna Beach, California

04645
Replaced by 75376

04713
Motorola Inc. Semiconductor
Products
Phoenix, Arizona

04946
Standard Wire & Cable
Los Angeles, California

05082
Replaced by 94988

05236
Jonathan Mfg. Co.
Fullerton, California

05245
Components Corp. now
Corcom, Inc.
Chicago, Illinois

05277
Westinghouse Electric Corp.
Semiconductor Div.
Youngwood, Pennsylvania

05278
Replaced by 43543

05279
Southwest Machine &
Plastic Co.
Glendora, California

05397
Union Carbide Corp.
Materials Systems Div.
New York, New York

05571
Use 56289
Sprague Electric Co.
Pacific Div.
Los Angeles, California

05574
Viking Industries
Chatsworth, California

05704
Replaced by 16258

05820
Wakefield Engineering Inc.
Wakefield, Massachusetts

06001
General Electric Co.
Electronic Capacitor &
Battery Products Dept.
Columbia, South Carolina

06136
Replaced by 63743

06383
Panduit Corp.
Tinley Park, Illinois

06473
Bunker Ramo Corp.
Amphenol SAMS Div.
Chatsworth, California

06555
Beede Electrical Instrument Co.
Penacook, New Hampshire

06739
Electron Corp.
Littleton, Colorado

06743
Clevite Corp.
Cleveland, Ohio

06751
Components, Inc. Semcor Div.
Phoenix, Arizona

06860
Gould Automotive Div.
City of Industry, California

06961
Vernitron Corp., Piezo
Electric Div.
Formerly Clevite Corp., Piezo
Electric Div.
Bedford, Ohio

06980
Eimac Div.
Varian Associates
San Carlos, California

07047
The Ross Milton Co.
South Hampton, Pennsylvania

07115
Replaced by 14674

07138
Westinghouse Electric Corp.,
Electronic Tube Div.
Horsehead, New York

07233
TRW Electronic Components
Cinch Graphic
City of Industry, California

07256
Silicon Transistor Corp.
Div. of BBF Group Inc.
Chelmsford, Massachusetts

07261
Aumet Corp.
Culver City, California

07263
Fairchild Semiconductor
Div. of Fairchild Camera
& Instrument Corp.
Mountain View, California

07344
Bircher Co., Inc.
Rochester, New York

07597
Burndy Corp.
Tape/Cable Div.
Rochester, New York

07792
Lerma Engineering Corp.
Northampton, Massachusetts

07910
Teledyne Semiconductor
Formerly Continental Device
Hawthorne, California

07933
Use 49956
Raytheon Co.
Semiconductor Div. HQ
Mountain View, California

08225
Industro Transistor Corp.
Long Island City, New York

## Federal Supply Codes for Manufacturers (cont)

08261
Spectra Strip Corp.
Garden Grove, California

08530
Reliance Mica Corp.
Brooklyn, New York

08806
General Electric Co.
Miniature Lamp Products Dept
Cleveland, Ohio

08863
Nylomatic Corp.
Norrisville, Pennsylvania

08988
Use 53085
Skottie Electronics Inc.
Archbald, Pennsylvania

09214
G.E. Co. Semi-Conductor
Products Dept.
Power Semi-Conductor
Products OPN Sec.
Auburn, New York

09353
C and K Components
Watertown, Massachusetts

09423
Scientific Components, Inc.
Santa Barbara, California

09922
Burndy Corp.
Norwalk, Connecticut

09969
Dale Electronics Inc.
Yankton, S. Dakota

10059
Barker Engineering Corp.
Formerly Amerace, Amerace
ESNA Corp.
Kenilworth, New Jersey

11236
CTS of Berne
Berne, Indiana

11237
CTS Keene Inc.
Paso Robles, California

11358
CBS Electronic Div.
Columbia Broadcasting System
Newburyport, Minnesota

11403
Best Products Co.
Chicago, Illinois

11503
Keystone Columbia Inc.
Warren, Michigan

11532
Teledyne Relays
Hawthorne, California

11711
General Instrument Corp.
Rectifier Division
Hicksville, New York

11726
Qualidyne Corp.
Santa Clara, California

12014
Chicago Rivet & Machine Co.
Bellwood, Illinois

12040
National Semiconductor Corp.
Danburry, Connecticut

12060
Diodes, Inc.
Chatsworth, California

12136
Philadelphia Handle Co.
Camden, New Jersey

12300
Potter-Brumfield Div.
AMF Canada LTD.
Guelph, Ontario, Canada

12323
Presin Co., Inc.
Shelton, Connecticut

12327
Freeway Corp. formerly
Freeway Washer & Stamping Co.
Cleveland, Ohio

12443
The Budd Co. Polychem Products
Plastic Products Div.
Bridgeport, Pennsylvania

12615
U.S. Terminals Inc.
Cincinnati, Ohio

12617
Hamlin Inc.
Lake Mills, Wisconsin

12697
Clarostat Mfg. Co.
Dover, New Hampshire

12749
James Electronics
Chicago, Illinois

12856
Micrometals
Sierra Madre, California

12954
Dickson Electronics Corp.
Scottsdale, Arizona

12969
Unitrode Corp.
Watertown, Massachusetts

13103
Thermalloy Co., Inc.
Dallas, Texas

13327
Solitron Devices Inc.
Tappan, New York

13511
Amphenol Cadre Div.
Bunker-Ramo Corp.
Los Gatos, California

13606
Use 56289
Sprague Electric Co.
Transistor Div.
Concord, New Hampshire

13839
Replaced by 23732

14099
Semtech Corp.
Newbury Park, California

14140
Edison Electronic Div.
Mc Gray-Edison Co.
Manchester, New Hampshire

14193
Cal-R-Inc. formerly
California Resistor, Corp.
Santa Monica, California

14298
American Components, Inc.
an Insilco Co.
Conshohocken, Pennsylvania

14655
Cornell-Dublier Electronics
Division of Federal Pacific
Electric Co. Govt. Control Dept.
Newark, New Jersey

14752
Electro Cube Inc.
San Gabriel, California

14869
Replaced by 96853

14936
General Instrument Corp.
Semi Conductor Products Group
Hicksville, New York

15636
Elec-Trol Inc.
Saugus, California

15801
Fenwal Electronics Inc.
Div. of Kidde Walter and Co., Inc.
Framingham, Massachusetts

15818
Teledyne Semiconductors,
formerly Amelco Semiconductor
Mountain View, California

15849
Litton Systems Inc. Useco Div.
formerly Useco Inc.
Van Nuys, California

15898
International Business
Machines Corp.
Essex Junction, Vermont

15909
Replaced by 14140

16258
Space-Lok Inc.
Burbank, California

16299
Corning Glass
Electronic Components Div.
Raleigh, North Carolina

16332
Replaced by 28478

16473
Cambridge Scientific Ind.
Div. of Chemed Corporation
Cambridge, Maryland

16742
Paramount Plastics
Fabricators, Inc.
Downey, California

16758
Delco Electronics
Div. of General Motors Corp.
Kokomo, Indiana

17001
Replaced by 71468

17069
Circuit Structures Lab.
Burbank, California

17338
High Pressure Eng. Co., Inc.
Oklahoma City, Oklahoma

17545
Atlantic Semiconductors, Inc.
Asbury Park, New Jersey

17856
Siliconix, Inc.
Santa Clara, California

17870
Replaced by 14140

18178
Vactec Inc.
Maryland Heights, Missouri

18324
Signetics Corp.
Sunnyvale, California

18612
Vishay Resistor Products Div.
Vishay Intertechnology Inc.
Malvern, Pennsylvania

18736
Voltronics Corp.
Hanover, New Jersey

18927
GTE Sylvania Inc.
Precision Material Group
Parts Division
Titusville, Pennsylvania

19451
Perine Machinery & Supply Co.
Seattle, Washington

19701
Electro-Midland Corp.
Mepco-Electra Inc.
Mineral Wells, Texas

20584
Enochs Mfg. Inc.
Indianapolis, Indiana

## Federal Supply Codes for Manufacturers (cont)

20891
Self-Organizing Systems, Inc.
Dallas, Texas

21604
Bucheye Stamping Co.
Columbus, Ohio

21845
Solitron Devices Inc.
Transistor Division
Riveria Beach, Florida

22767
ITT Semiconductors
Palo Alto, California

23050
Product Comp. Corp.
Mount Vernon, New York

23732
Tracor Inc.
Rockville, Maryland

23880
Stanford Applied Engrng.
Santa Clara, California

23936
Pamotor Div., Wm. J. Purdy Co.
Burlingame, California

24248
Replaced by 94222

24355
Analog Devices Inc.
Norwood, Massachusetts

24655
General Radio
Concord, Massachusetts

24759
Lenox-Fugle Electronics Inc.
South Plainfield, New Jersey

25088
Siemen Corp.
Isilen, New Jersey

25403
Amperex Electronic Corp.
Semiconductor &
Micro-Circuits Div.
Slatersville, Rhode Island

27014
National Semiconductor Corp.
Santa Clara, California

27264
Molex Products
Downers Grove, Illinois

28213
Minnesota Mining & Mfg. Co.
Consumer Products Div.
St. Paul, Minnesota

28425
Serv-/-Link formerly
Bohannan Industries
Fort Worth, Texas

28478
Deltrol Controls Div.
Deltrol Corporation
Milwaukee, Wisconsin

28480
Hewlett Packard Co.
Corporate HQ
Palo Alto, California

28520
Heyman Mfg. Co.
Kenilworth, New Jersey

29083
Monsanto, Co., Inc.
Santa Clara, California

29604
Stackpole Components Co.
Raleigh, North Carolina

30148
AB Enterprise Inc.
Ahoskie, North Carolina

30323
Illinois Tool Works, Inc.
Chicago, Illinois

31091
Optimax Inc.
Colmar, Pennsylvania

32539
Mura Corp.
Great Neck, New York

32767
Griffith Plastic Corp.
Burlingame, California

32879
Advanced Mechanical
Components
Northridge, California

32897
Erie Technological Products, Inc.
Frequency Control Div.
Carlisle, Pennsylvania

32997
Bourns Inc.
Trimpot Products Division
Riverside, California

33173
General Electric Co.
Products Dept.
Owensboro, Kentucky

34333
Silicon General
Westminister, California

34335
Advanced Micro Devices
Sunnyvale, California

34802
Electromotive Inc.
Kenilworth, New Jersey

37942
P.R. Mallory & Co., Inc.
Indianapolis, Indiana

42498
National Radio
Melrose, Massachusetts

43543
Nytronics Inc.
Transformer Co. Div.
Geneva, New York

44655
Ohmite Mfg. Co.
Skokie, Illinois

49671
RCA Corp.
New York, New York

49956
Raytheon Company
Lexington, Massachusetts

50088
Mostek Corp.
Carrollton, Texas

50579
Litronix Inc.
Cupertino, California

51605
Scientific Components Inc.
Linden, New Jersey

53021
Sangamo Electric Co.
Springfield, Illinois

54294
Cutler-Hammer Inc. formerly
Shallcross, A Cutter-Hammer Co.
Selma, North Carolina

55026
Simpson Electric Co.
Div. of Am. Gage and Mach. Co.
Elgin, Illinois

56289
Sprague Electric Co.
North Adams, Massachusetts

58474
Superior Electric Co.
Bristol, Connecticut

60399
Torin Corp. formerly
Torrington Mfg. Co.
Torrington, Connecticut

63743
Ward Leonard Electric Co., Inc.
Mount Vernon, New York

64834
West Mfg. Co.
San Francisco, California

65092
Weston Instruments Inc.
Newark, New Jersey

66150
Winslow Tele-Tronics Inc.
Eaton Town, New Jersey

70485
Atlantic India Rubber Works
Chicago, Illinois

70563
Amperite Company
Union City, New Jersey

70903
Belden Corp.
Geneva, Illinois

71002
Birnback Radio Co., Inc.
Freeport, New York

71400
Bussmann Mfg.
Div. of McGraw-Edison Co.
Saint Louis, Missouri

71450
CTS Corp.
Elkhart, Indiana

71468
ITT Cannon Electric Inc.
Santa Ana, California

71482
Clare, C.P. & Co.
Chicago, Illinois

71590
Centrelab Electronics
Div. of Globe Union Inc.
Milwaukee, Wisconsin

71707
Coto Coil Co., Inc.
Providence, Rhode Island

71744
Chicago Miniature Lamp Works
Chicago, Illinois

71785
TRW Electronics Components
Cinch Connector Operations Div.
Elk Grove Village
Chicago, Illinois

72005
Wilber B. Driver Co.
Newark, New Jersey

72092
Replaced by 06980

72136
Electro Motive Mfg. Co.
Williamantic, Connecticut

72259
Nytronics Inc.
Pelham Manor, New Jersey

72619
Dialight Div.
Amperex Electronic Corp.
Brooklyn, New York

72653
G.C. Electronics
Div. of Hydrometals, Inc.
Brooklyn, New York

72665
Replaced by 90303

72794
Dzus Fastener Co., Inc.
West Islip, New York

72928
Gulton Ind. Inc.
Gudeman Div
Chicago, Illinois

## Federal Supply Codes for Manufacturers (cont)

72982
Erie Tech. Products Inc.
Erie, Pennsylvania

73138
Bechman Instrument Inc.
Helipot Division
Fullerton, California

73293
Hughes Aircraft Co.
Electron Dynamics Div.
Torrance, California

73445
Amperex Electronic Corp.
Hicksville, New York

73559
Carling Electric Inc.
West Hartford, Connecticut

73586
Circle F Industries
Trenton, New Jersey

73734
Federal Screw Products, Inc.
Chicago, Illinois

73743
Fischer Special Mfg. Co.
Cincinnati, Ohio

73899
JFD Electronics Co.
Components Corp.
Brooklyn, New York

73949
Guardian Electric Mfg. Co.
Chicago, Illinois

74199
Quan Nichols Co.
Chicago, Illinois

74217
Radio Switch Corp.
Marlboro, New Jersey

74276
Signalite Div.
General Instrument Corp.
Neptune, New Jersey

74306
Piezo Crystal Co.
Carlisle, Pennsylvania

74542
Hoyt Elect. Instr. Works
Penacook, New Hampshire

74970
Johnson E.F., Co.
Waseca, Minnesota

75042
TRW Electronics Components
IRC Fixed Resistors
Philadelphia, Pennsylvania

75376
Kurz-Kasch Inc.
Dayton, Ohio

75378
CTS Knights Inc.
Sandwich, Illinois

75382
Kulka Electric Corp.
Mount Vernon, New York

75915
Littlefuse Inc.
Des Plaines, Illinois

76854
Oak Industries Inc.
Switch Div.
Crystal Lake, Illinois

77342
AMF Inc.
Potter & Brumfield Div.
Princeton, Indiana

77638
General Instrument Corp.
Rectifier Division
Brooklyn, New York

77969
Rubbercraft Corp. of CA. LTD.
Torrance, California

78189
Shakeproof
Div. of Illinois Tool Works Inc.
Elgin, Illinois

78277
Sigma Instruments, Inc.
South Braintree, Massachusetts

78488
Stackpole Carbon Co.
Saint Marys, Pennsylvania

78553
Eaton Corp. Engineered
Fastener Div.
Tinnerman Plant
Cleveland, Ohio

79136
Waldes Kohinoor Inc.
Long Island City, New York

79497
Western Rubber Company
Goshen, Indiana

79963
Zierick Mfg. Corp.
Mt. Kisko, New York

80031
Electro-Midland Corp.
Mepco Div.
A North American Phillips Co.
Norristown, New Jersey

80145
LFE Corp., Process Control Div.
formerly API Instrument Co.
Chesterland, Ohio

80183
Use 56289
Sprague Products
North Adams, Massachusetts

80294
Bourns Inc., Instrument Div.
Riverside, California

80583
Hammarlund Mfg. Co., Inc.
Red Bank, New Jersey

80640
Arnold Stevens, Inc.
South Boston, Massachusetts

81073
Grayhill, Inc.
La Grange, Illinois

81312
Winchester Electronics
Div. of Litton Industries Inc.
Oakville, Connecticut

81483
Therm-O-Disc Inc.
Mansfield, Ohio

81483
International Rectifier Corp.
Los Angeles, California

81590
Korry Mfg. Co.
Seattle, Washington

81741
Chicago Lock Co.
Chicago, Illinois

82305
Palmer Electronics Corp.
South Gate, California

82389
Switchcraft Inc.
Chicago, Illinois

82415
North American Phillips
Controls Corp.
Frederick, Maryland

82872
Roanwell Corp.
New York, New York

82877
Rotron Inc.
Woodstock, New York

82879
ITT Royal Electric Div.
Pawtucket, Rhode Island

83003
Varo Inc.
Garland, Texas

83058
The Carr Co., United Can Div.
of TRW
Cambridge, Massachusetts

83298
Bendix Corp.
Electric Power Div.
Eatontown, New Jersey

83330
Herman H. Smith, Inc.
Brooklyn, New York

83478
Rubbercraft Corp.
of America, Inc.
West Haven, Connecticut

83594
Burroughs Corp.
Electronic Components Div.
Plainfield, New Jersey

83740
Union Carbide Corp.
Battery Products Div.
formerly Consumer Products Div.
New York, New York

84171
Arco Electronics
Great Neck, New York

84411
TRW Electronic Components
TRW Capacitors
Ogallala, Nebraska

84613
Fuse Indicator Corp.
Rockville, Maryland

84682
Essex International Inc.
Industrial Wire Div.
Peabody, Massachusetts

86577
Precision Metal Products
of Malden Inc.
Stoneham, Massachusetts

86684
Radio Corp. of America
Electronic Components Div.
Harrison, New Jersey

86928
Seastrom Mfg. Co., Inc.
Glendale, California

87034
Illuminated Products Inc.
Subsidiary of Oak Industries Inc.
Anahiem, California

88219
Gould Inc.
Industrial Div.
Trenton, New Jersey

88245
Litton Systems Inc.
Useco Div.
Van Nuys, California

88419
Cornell-Dubilier Electronic Div.
Federal Pacific Co.
Fuquay-Varian, North Carolina

88486
Plastic Wire & Cable
Jewitt City, Connecticut

88690
Replaced by 04217

89536
John Fluke Mfg. Co., Inc.
Seattle, Washington

89730
G.E. Co., Newark Lamp Works
Newark, New Jersey

## Federal Supply Codes for Manufacturers (cont)

90201
Mallory Capacitor Co.
Div. of P.R. Mallory Co., Inc.
Indianapolis, Indiana

90211
Use 56365
Square D Co.
Chicago, Illinois

90215
Best Stamp & Mfg. Co.
Kansas City, Missouri

90303
Mallory Battery Co.
Div. of Mallory Co., Inc.
Tarrytown, New York

91094
Essex International Inc.
Suglex/IWP Div.
Newmarket, New Hampshire

91293
Johanson Mfg. Co.
Boonton, New Jersey

91407
Replaced by 58474

91502
Associated Machine
Santa Clara, California

91506
Augat Inc.
Attleboro, Massachusetts

91637
Dale Electronics Inc.
Columbus, Nebraska

91662
Elco Corp.
Willow Grove, Pennsylvania

91737
Use 71468
Gremar Mfg. Co., Inc.
ITT Cannon/Gremar
Santa Ana, California

91802
Industrial Devices, Inc.
Edgewater, New Jersey

91833
Keystone Electronics Corp.
New York, New York

91836
King's Electronics Co., Inc.
Tuckahoe, New York

91929
Honeywell Inc.
Micro Switch Div.
Freeport, Illinois

91934
Miller Electric Co., Inc.
Div. of Aunet
Woonsocket, Rhode Island

92194
Alpha Wire Corp.
Elizabeth, New Jersey

93332
Sylvania Electric Products
Semiconductor Products Div.
Woburn, Massachusetts

94145
Replaced by 49956

94154
Use 94988
Wagner Electric Corp.
Tung-Sol Div.
Newark, New Jersey

94222
Southco Inc. formerly
South Chester Corp.
Lester, Pennsylvania

95146
Alco Electronic Products Inc.
Lawrence, Massachusetts

95263
Leecraft Mfg. Co.
Long Island City, New York

95264
Replaced by 98278

95275
Vitramon Inc.
Bridgeport, Connecticut

95303
RCA Corp.
Receiving Tube Div.
Cincinnati, Ohio

95348
Gordo's Corp.
Bloomfield, New Jersey

95354
Methode Mfg. Corp.
Rolling Meadows, Illinois

95712
Bendix Corp.
Electrical Components Div.
Microwave Devices Plant
Franklin, Indiana

95987
Weckesser Co. Inc.
Chicago, Illinois

96733
San Fernando Electric Mfg. Co.
San Fernando, California

96853
Gulton Industries Inc.
Measurement and Controls Div.
formerly Rustrak Instruments Co.
Manchester, New Hampshire

96881
Thomson Industries, Inc.
Manhasset, New York

97540
Master Mobile Mounts, Div. of
Whitehall Electronics Corp.
Ft. Meyers, Florida

97913
Industrial Electronic
Hardware Corp.
New York, New York

97945
Penwalt Corp.
SS White Industrial Products Div.
Piscataway, New Jersey

97966
Replaced by 11358

98094
Replaced by 49956

98159
Rubber-Teck, Inc.
Gardena, California

98278
Malco A Microdot Co., Inc.
Connector & Cable Div.
Pasadena, California

98291
Sealectro Corp.
Mamaroneck, New York

98388
Royal Industries
Products Div.
San Diego, California

98743
Replaced by 12749

98925
Replaced by 14433

99120
Plastic Capacitors, Inc.
Chicago, Illinois

99217
Bell Industries Elect.
Comp. Div.
formerly Southern Elect. Div.
Burbank, California

99392
STM
Oakland, California

99515
ITT Jennings Monrovia Plant
Div. of ITT Jennings formerly
Marshall Industries Capacitor Div.
Monrovia, California

99779
Use 29587
Bunker-Ramo Corp.
Barnes Div.
Landsdowne, Pennsylvania

99800
American Precision Industries Inc.
Delevan Division
East Aurora, New York

99942
Centrelab Semiconductor
Centrelab Electronics Div. of
Globe-Union Inc.
El Monte, California

Toyo Electronics
(R-Ohm Corp.)
Irvine, California

National Connector
Minneapolis, Minnesota

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3322 S. Memorial Parkway
Suite 96
Huntsville, AL 35801
(205) 881-6220

**AZ, Tempe**
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2125 S. 48th Street
Suite 104
Tempe, AZ 85282
(602) 967-8724

**Tucson**
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20902 South Bonita St.
Carson, CA 90746
(213) 538-3900
or (714) 761-2449

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John Fluke Mfg. Co., Inc.
9601 Aero Drive, Suite 290
San Diego, CA 92123
(714) 226-1254

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(408) 727-0513

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John Fluke Mfg. Co., Inc.
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41-C New London Turnpike
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Orlando, FL 32803
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(404) 953-4747

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Honolulu, HI 96819
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Rolling Meadows, IL 60008
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Suite 101
Indianapolis, IN 46268
(317) 875-7870

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Shawnee Mission, KA 66211
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Livonia, MI 48154
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Bloomington, MN 55420
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St. Louis, MO 63141
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(919) 273-1918

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John Fluke Mfg. Co., Inc.
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Paramus, NJ 07652
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(215) 265-4040

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(412) 261-5171

**TX, Austin**
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Creek Gardens, Suite 103
8705 Shoal Creek Blvd.
Austin, TX 78758
(512) 459-3344

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14400 Midway Road
Dallas, TX 75234
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John Fluke Mfg. Co., Inc.
4240 Blue Bonnet Dr.
Stafford, TX 77477
(713) 491-5995

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John Fluke Mfg. Co., Inc.
10417 Gulfdale
San Antonio, TX 78216
(512) 340-2621

**UT, Salt Lake City**
John Fluke Mfg. Co., Inc.
5226 So. 300 West, Suite #2
Salt Lake City, UT 84107
(801) 268-9331

**WA, Seattle**
John Fluke Mfg. Co., Inc.
5020 148th Ave. N.E.
Suite #110
Redmond, WA 98052
(206) 881-6966

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Elmeasco Instruments Pty Ltd.
21-23 Anthony Drive
Mt. Waverly, VIC 3149
Australia
Tel: 233-4044, TLX: (790) 36206

Elmeasco Instruments Pty Ltd.
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Tel: (09) 398-3362

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Elektronische Gerate GmbH & Co.
Vertrieb KG
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Tel: (0222) 235555, TLX: 134759

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24 Hatkhola Rd., Tikatuli
Dacca 3, Bangladesh
Tel: 257249 or 255776

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6, Rue de Geneve
1140 Brussels, Belgium
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Fluke Brasil-Industria E
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Manuel Montt 024 - Of. D
Casilla 16228, Santiago 9, Chile
Tel: 44940, TLX: 240301
Attn: Intronica Chile

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Proteco Coasin Cia., Ltda.
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Rapifax: (0923) 25067

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78530 BUC
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78530 BUC, France
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Rapifax: (089) 9605166

Fluke (Deutschland) GmbH
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TLX: 74766

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Tel: 811316, TLX: 112326

Hinditron Services Pvt. Ltd.
8th Main Road
33/44-A Raj Mahl Vilas Extension
Bangalore 560 080, India
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Hinditron Services Pvt. Ltd.
Shantiniketan, Office No.6
6th Floor, 8 Camac Street
Calcutta 700 017, India
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Hinditron Services Pvt. Ltd.
204-206 Henkunt Tower
98 Nehri Place
New Delhi, 110019, India
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Tel: (46) 23577, TLX: (851) 3182

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00143 Rome, Italy
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Sistrel S.p.A.
Via Cinto
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80126 Naples, Italy
Tel: (81) 7679700

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Japan Branch
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Shinbashi Bldg.
1-1-11 Hamamatsucho
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P O Box 30070
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Tel 331955, TLX. 22639

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Room 403, Boondo Bldg
56-12 Jangchung-IKa
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Sultanate of Oman
Tel 702666 or 703862
TLX 3168

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Spark Radio & Electronics Corp
Greenhills P O Box 610
San Juan, Metro-Manila
Philippines Zip 3113
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**Saudi Arabia ■**
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Riyadh, Saudi Arabia
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**Singapore ●**
Rank O'Connor's (PTE) Limited
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Colombo 5, Sri Lanka
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**Sweden ■**
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P.O. Box 4490
162 04 Vallingby, Sweden
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**Switzerland ■**
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**Syria ■**
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Damascus, Syria

**Taiwan ●**
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Taipei, Taiwan
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**Thailand ●**
Measuretronix Ltd
1899/10 Ramkamhaeng Rd
Huamark, Bangkok 24, Thailand
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**Tunesia ■**
Selep S A.R L
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**Turkey ■**
Erkman Elektronik Aletler
Ticaret Anonim Sirketi
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Karakoy, Istanbul, Turkey
Tel: 441546
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**United Arab Emirates ■**
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(305) 896-2296

**IL, Rolling Meadows**
John Fluke Mfg. Co., Inc.
(312) 398-5800

**MA, Burlington**
John Fluke Mfg. Co., Inc.
(617) 273-4678

**MD, Rockville**
John Fluke Mfg. Co., Inc.
(301) 770-1576

**NJ, Paramus**
John Fluke Mfg. Co., Inc.
(201) 262-9550

**TX, Dallas**
John Fluke Mfg. Co., Inc.
(214) 233-9945

**WA, Everett**
John Fluke Mfg. Co., Inc.
(206) 356-5560

## Other Countries

**Argentina, Buenos Aires**
Coasin S.A.
Tel: 552-5248/3485
TLX: 122284 COASN AR

**Australia, Concord**
Elmeasco Instruments Pty Ltd.
Tel: (02) 736-2888
TLX: (790) 25887

**Australia, Mount Waverley**
Elmeasco Instruments Pty Ltd.
Tel: 03-233-4044
TLX: 36206

**Australia, Brisbane**
Elmeasco Instruments Pty Ltd.
Tel: (07) 229-3161

**Austria, Vienna**
Walter Rekirsch Electronische Gerate
GmbH & Co.
Tel: (0222) 235555
TLX: 134759

**Belgium, Brussels**
Fluke (Belgium) SA/NA
Tel: (02) 2164090
TLX: 26312

**Brazil, Sao Paulo**
Fluke Brasil-Industria E Comercio Ltda.
Tel: (011) 421-3603
TLX: 01135589 FLKE BR

**Canada, Calgary, AB**
Allan Crawford Associates Ltd
Tel: (403) 230-1341

**Canada, Burnaby, BC**
Allan Crawford Associates Ltd.
Tel: (604) 294-1326

**Canada, Mississauga, ON**
Allan Crawford Associates Ltd.
Tel: (416) 678-1500

**Canada, St. Laurent, PQ**
Allan Crawford Associates Ltd.
Tel: (514) 731-8564

**Chile, Santiago**
Intronica Chile Ltda.
Tel: 44940
TLX: 240301

**China, Beijing**
Beijing Radio Research Institute
Tel: 445612

**Colombia, Bogota**
Sistemas E Instrumentacion, Ltda.
Tel: 232-45-32
TLX: 45787 COASN CO

**Denmark, Ballerup**
Tage Olsen A/S
Tel: (02) 658111
TLX: 35293 TOAS SK

**Ecuador, Quito**
Edificio "Jerico"
Tel: 529684, 526759
TLX: 2865 Protec Ed

**Egypt, Cairo**
Electronic Engineering Liaison Office
Tel: 691588
TLX: (927) 92502

**England, Watford, Herts**
Fluke (Great Britain) LTD
Tel: 44-923-40511
TLX: 934583

**Finland, Kauniainen**
Oy Findip AB
Tel: (0) 5052255
TLX: 123129

**France, BUC**
M.B. Electronique S.A.
Tel: (01) 9568131
TLX: 695414

**Greece, Athens**
Hellenic Scientific Representations
Tel: (01) 711140
TLX: 219330

**Hong Kong, Hong Kong**
Schmidt & Co. (H.K.) Ltd.
Tel: 5-455644
TLX: 74766 SCHMC HX

**India, Bombay**
Hinditron Services Pvt. Ltd.
Tel: 811316, 815344
TLX: 953-112326 HSPL IN

**India, Bangalore**
Hinditron Services Pvt. Ltd.
Tel: 33139
TLX: 0845741

**India, New Delhi**
Hinditron Services Pvt. Ltd.
Tel: 619118
TLX: 031 4890 SRMP IN

**Indonesia, Jakarta Selatan**
P.T. Dwi Tunggal Jaya Sakti
Tel: 716374
TLX: 47308 DIJS IA

**Israel, Ramat Hasharon**
R.D.T. Electronics Engineering Ltd.
Tel: (03) 483216
TLX: 32143

**Italy, Milan**
Sistrel S.p.A.
Tel: (02) 6181893
TLX: 334643

**Italy, Rome**
Sistrel S.p.A.
Tel: (06) 5915551
TLX: 68356

**Japan, Tokyo**
John Fluke Mfg. Co., Inc.
Japan Branch
Tel: (03) 434-0181
TLX: (781) 2424331 (FLUKJPJ)

**Korea, Seoul**
Electro-Science Korea Co.
Tel: 261-7702, 260-1908
TLX: K25381

**Malaysia, Petaling Jaya**
Mecomb Malaysia SDN BHD
Tel: 573455
TLX: MA37605

**Mexico, Mexico D.F.**
Electronica y Tecnologia
Avanzada S.A. de C.V. (ETA)
Tel: 393 09 02 or 393 57 62
TLX: 0172697 BLOSME

**Netherlands, Maarssen**
Fluke (Nederland) B.V.
Tel: (030) 436514
TLX: 47128

**Netherlands, Tilburg**
Fluke (Holland) B.V.
Tel: (013) 673973
TLX: 52237

**New Zealand, Auckland**
McLean Information Technology, Ltd.
Tel: 501-801, 501-219, 587-037
TLX: NZ21570 THERMAL

**Norway, Oslo**
Morgenstierne & Co A/S
Tel: (02) 356110
TLX: 71719

**Pakistan, Karachi**
Pak International Operations
Tel: 221127, 239052
TLX: 24494 PIO PK

**Peru, Lima**
Importaciones Y Representaciones
Electronicas S.A.
Tel: 288650
TLX: 37425663

**Philippines, Metro Manila**
Spark Radio & Electronics Corp.
Tel: 78-78-16
TLX: 27901 RLA PH

**Portugal, Lisboa**
Decada-Equipamentos de
Electronica, Lda.
Tel: (19) 574984
TLX: 18469

**Republic of Singapore, Singapore**
Rank O'Connor's (PTE) Limited
Tel: 637944, 239052
TLX: OCONSIN RS21023

**Republic of South Africa, Bramley**
Fluke S.A. (Pty) Ltd.
Tel: (011) 786-3170
TLX: 424328

**Spain, Alcorcon (Madrid)**
Hispano Electronics S.A.
Tel: (01) 6194108
TLX: 22404/42634

**Sweden, Vallingby**
Teleinstrument AB
Tel: (08) 380370
TLX: 15770

**Switzerland, Zurich**
Traco Electronic AG
Tel: (01) 2010711
TLX: 54318

**Taiwan, Taipei**
Schmidt Scientific Far East Ltd.
Tel: 5414600
TLX: 11111 Schmidt

**Thailand, Bangkok**
Measuretronix Ltd.
Tel: 3143369, 3143430
TLX: 81143 DEJOBKK TH

**Turkey, Istanbul**
Erkman Elektronik Aletler
Tel: (01) 5461
TLX: 23353

**Uruguay, Montevideo**
Coasin Uruguaya S.R.L.
Tel: 29-31-952
TLX: UY 6571 OROCUER

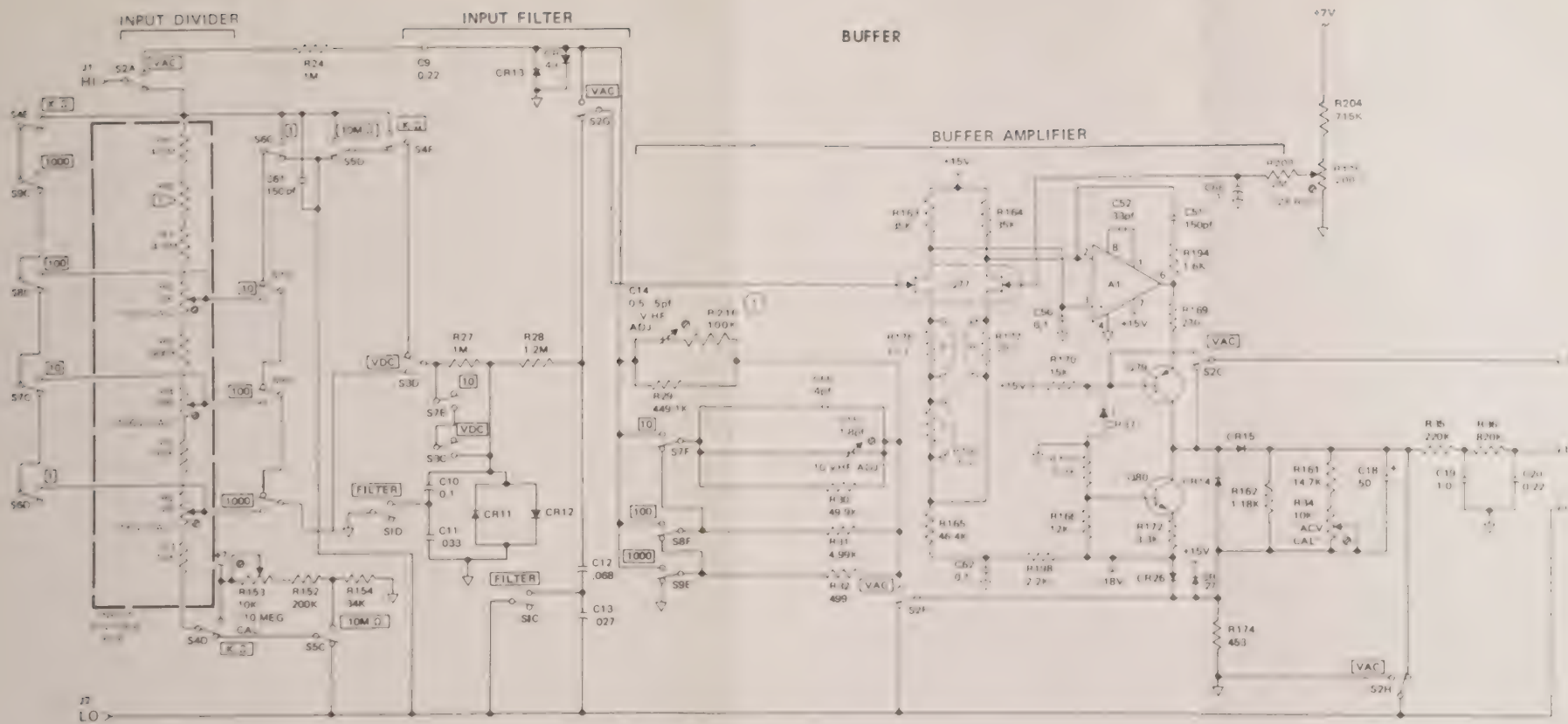
**Venezuela, Caracas**
Coasin, C.A.
Tel: 38-78-42, 38-78-86
TLX: 21027 EMVEN VE

**West Germany, Ismaning**
Fluke (Deutschland) GmbH
Tel: (089) 96050
TLX: 0522472

FLUKE®
John Fluke Mfg. Co., Inc., P.O. Box C9090, Everett, WA 98206
Fluke (Holland) B.V., P.O. Box 5053, 5004 EB, Tilburg, The Netherlands. Phone (013) 673973
Litho in U.S.A. 1/83

# Section 8
# Schematic Diagrams

| | |
|---|---|
| **SCHEMATIC DIAGRAMS** | No. 1 thru No. 3 |
| **SCHEMATIC DIAGRAM DRAWING NO.** | 8100A-02-1002 |




**CHANGES:**

(1) R216 ADDED S/N 435 AND ON.

**NOTES;**

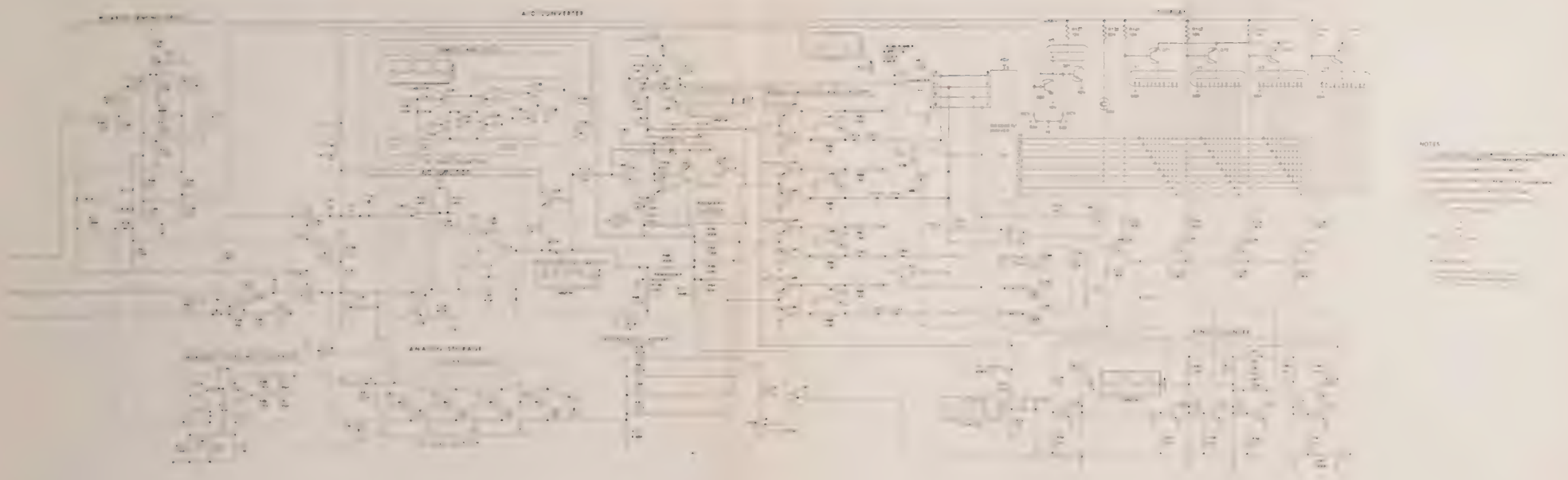
1. ALL RESISTANCES IN OHMS AND ALL CAPACITANCES IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
2. ALL SWITCHES SHOWN IN OFF POSITION.
3. ⊘ DENOTES INTERNAL SCREWDRIVER ADJUSTMENT.
4. ▭ DENOTES FRONT PANEL LOCATION.
5. (1) 15K OR 4.99K – FACTORY SELECTED AT TEST.

FUNCTIONAL SCHEMATIC DIAGRAM

MODEL 8110A
DIGITAL MULTIMETER

SCHEMATIC NO. 1

JOHN FLUKE MFG. CO., INC.
P.O. Box 7428 Seattle, Washington 98133



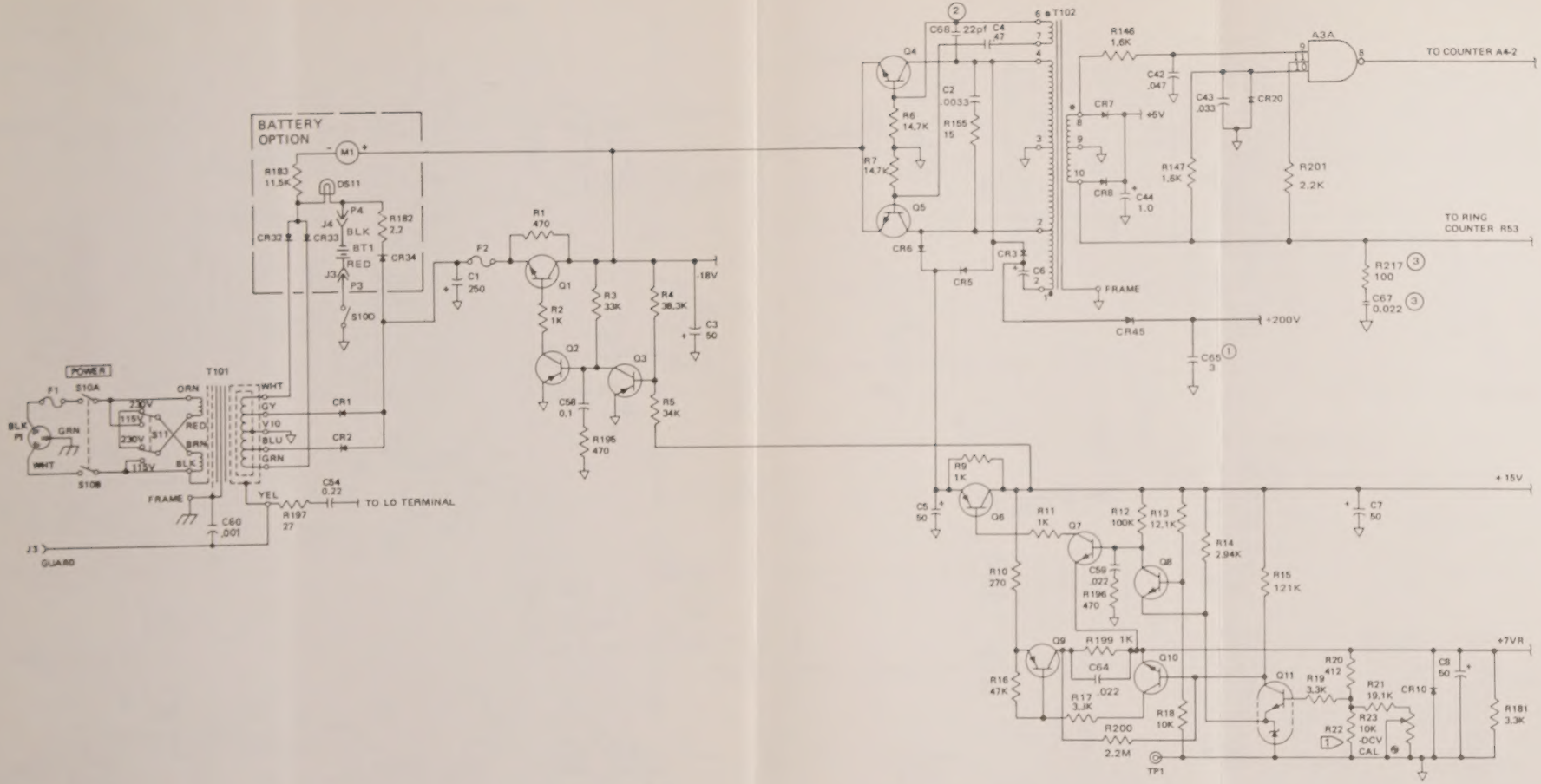
NOTES

FUNCTIONAL SCHEMATIC DIAGRAM

MODEL 8110A
DIGITAL MULTIMETER

SCHEMATIC NO. 2

FLUKE JOHN FLUKE MFG. CO., INC.
P.O. Box 7428 Seattle, Washington 98133




## CHANGES:

1. FOR S/N 123 THRU 316: C65 WAS 4uf
2. C68 ADDED S/N 435 AND ON
3. R217 AND C67 ADDED S/N 350 AND ON

## NOTES:

(1) VALUE SELECTED AT TEST OF Q11

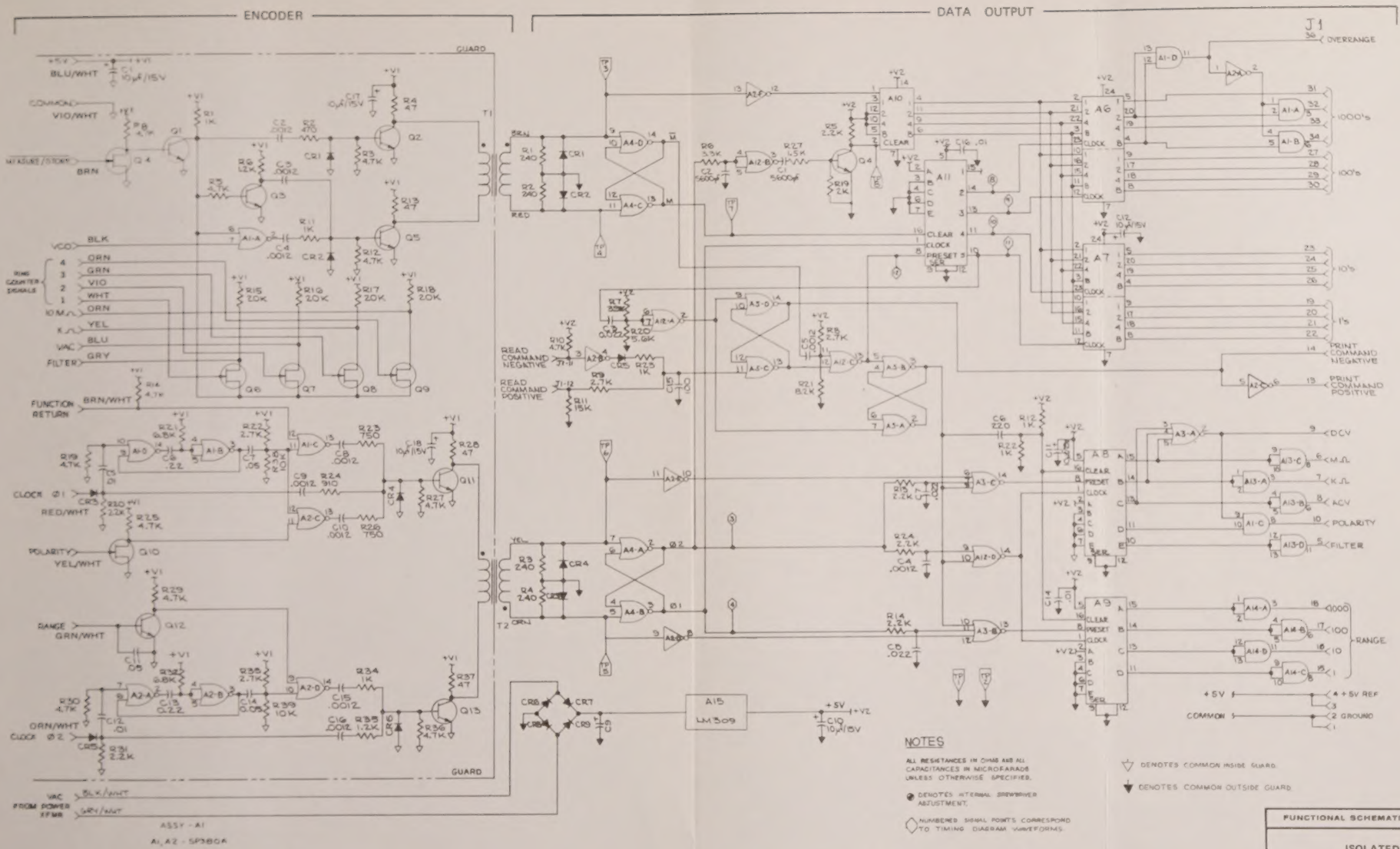
FUNCTIONAL SCHEMATIC DIAGRAM

MODEL 8110A
DIGITAL MULTIMETER

SCHEMATIC NO. 3

SER NO. 123 & ON — REV C

FLUKE JOHN FLUKE MFG. CO., INC.
P.O. Box 7428 Seattle, Washington 98133




NOTES

ALL RESISTANCES IN OHMS AND ALL CAPACITANCES IN MICROFARADS UNLESS OTHERWISE SPECIFIED.

● DENOTES INTERNAL SCREWDRIVER ADJUSTMENT.

◇ NUMBERED SIGNAL POINTS CORRESPOND TO TIMING DIAGRAM WAVEFORMS.

▽ DENOTES COMMON INSIDE GUARD.

▼ DENOTES COMMON OUTSIDE GUARD.

| FUNCTIONAL SCHEMATIC DIAGRAM | |
|---|---|
| ISOLATED PRINTER OUTPUT | |
| 8100A-02-1002 | REV A |

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